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Packed Sessions Hear Sharp Debates at Record Annual Meeting

Part of the crowd assembled to hear the speeches after the dinner on Thursday evening. Similar throngs listened to discussions at practically every session.

THREE thousand automotive engineers debated immediate problems, questioned more than one fundamental assumption upon which current practices have been developed and speculated startlingly about future automotive designs at the 30th Anniversary Annual Meeting of the Society of Automotive Engineers, Book-Cadillac Hotel, Detroit, Jan. 14 to 18.

Never has so stirring an S.A.E. meeting developed before. Total attendance broke all records by a wide margin. Consistently, individual sessions were packed to overflowing. Added together, the attendance at these individual discussion-points totaled well over 5000. New high standards were established for starting sessions on time, finishing them on time and generating a maximum of brisk discussion within a limited period—despite an obvious exception or two.

There was the usual exchange of ideas about immediate problems both in and out of the formal meeting rooms. But specific speculation about what is *going* to happen was far more plentiful than usual. Fresh angles on the rear-engine car and streamlining situation were developed. Practical experiments with rubber automobile springs were described. A vehicle in which one might fly to an airport, fold up the wings and drive home to one's garage was envisioned.

Fitting appropriately into a meeting of unusual happenings, for the first time a single paper was chosen by the entirely separate committees to receive both the Manly and the Wright Brothers medal awards for 1934. The awards were presented to the authors—Rex B. Beisel, A. Lewis MacClain and F. M. Thomas—at the Thursday evening dinner. Their double-winner paper was entitled "The Cowling and Cooling of Radial Air-Cooled Aircraft Engines", presented at the 1934 Annual Meeting of the Society, and was published in the May, 1934, issue of the S.A.E. Journal.

The Engineering Exhibit, now an annual meeting fixture, filled the Crystal Room and the parlors adjoining the main meeting room with a wealth of new devices and processes which stimulated the interest of practically every member and guest. Thirty-three companies showed special products in this "engineering exhibit for engineers" which emphasized, among other things, the major contribution which parts, accessory and material supplies continue to make to the progress of modern motor vehicle design.

Business Session Lively

The business session, not only found general agreement on important constitutional amendments presented for final reading before submission to the membership for letter ballot, but also voted favorably on a resolution presented by F. C. Patton of Los Angeles which read:

"It is the sense of this meeting that the annual Nominating Committee shall select one consenting candidate for each of the Vice-Presidencies representing a Professional Activity from the members active in each of the Professional Activities and shall report this list of candidates at the same time the nominations for the other offices are reported."

This resolution was passed on for consideration and discussion to the Council, to the Constitution Committee and to the Past-Presidents' Advisory Committee.

Later at a meeting of the Diesel-Engine Activity Committee, a motion was passed unanimously dissenting from the idea expressed in Mr. Patton's resolution. It read: "That it be the sense of this meeting that the Diesel Engine Activity

Committee recommends that the method of nominating Vice-Presidents of the Activities should not be changed, and that this recommendation be passed on to the Council for consideration."

The constitutional amendments presented for final reading before ballot by J. H. Hunt for the Constitution Committee were seven in number. They are proposed amendments to C-15, C-22, C-45, C-46, C-50A, C-54 and C-57 and were read as printed in the Nov., 1934, issue of the S.A.E. JOURNAL. In addition, Mr. Hunt submitted for the first reading C-24A, designed to provide for conferring Life Memberships upon future Presidents of the Society as has just been done in the case of Past-Presidents. (See page 32 of this issue.)

B. B. Bachman, W. S. James and J. H. Hunt were elected as delegates at large to the annual Nominating Committee at the Business Session.

The recently established Past-Presidents' Advisory Committee held its first session during this unusual Annual Meeting. Ten Past-Presidents attended and chose Col. H. W. Alden, the only man ever to have been twice President of the Society, as chairman.

Roos at Dinner Talks Progress

A high spot of the entire gathering was the Thursday dinner at which the Detroit Section was host to the general Society. It established a new record with an attendance in excess of 1000 and saw D. G. Roos, 1934 president, turn over his stewardship to President W. B. Stout with the words:

"The S.A.E. ship is on her course. She is sound in every rivet—so, I am happy to turn her over to a better pilot."

Stirring as well as encouraging was the rapid, factual story which Mr. Roos told of S.A.E. movement during the last twelve months.

In passing, Mr. Roos referred to a situation wherein, he said, personal political aspirations had seemed to take precedence over the accepted standards of professional ethics. Emphasizing the expressed attitude of the Council that the office should seek the man, President Roos reported that such departures from traditional practices as had taken place had been met by a united force of S.A.E. influence; further, he assured his listeners that like unanimity could be expected in the presence of any similar deviations that might arise in the future.

K. T. Keller, president, Dodge Bros., and vice-president and general manager, Chrysler Corp., long famous as one of the industry's outstanding executives, placed himself in the top-flight of toastmastership in presiding at this important dinner. C. R. Paton, chief engineer, Packard Motor Car Co. and Detroit Section Chairman, welcomed the Society to Detroit and characterized the spirit of those present as one of "intelligent optimism."

The chief speaker at the dinner was Philip Sporn, chief engineer, American Gas and Electric Co., who talked on "Major Problems in the Electric Light and Power Industry." Mr. Sporn spoke pointedly about the relation of power industry problems to the proposed entrance of the Government into the public utilities field. Stating that there is more danger in public than in private monopolies, Mr. Sporn characterized the Tennessee Valley Administration project as 50 per cent "Barnum" and 50 per cent "Popular Mechanics".

Late in 1934, he said, after considerable equipment for power had been purchased, the TVA hired some good consulting engineers to make recommendations as to the type of line to be put in. The recommendation of these engineers, according to Mr. Sporn, was that "no line be built."

Following Mr. Sporn's talk, William B. Stout, formally accepted his new duties as President of the Society for 1935, speaking a few brief words of welcome to the guests and greetings to the members.

Student Interest Growing

The Student Session, held on Monday evening, again was an outstanding phase of the big annual gathering. Both the large attendance of 1100 and the deep interest displayed brought added evidence of the constantly growing effectiveness of the student work which the Detroit Section has been sponsoring for some years. O. E. Kurt, chairman of the Detroit Section Student Activity for 1934, presided at this session at which H. R. Berlin, Johns-Manville Corp., gave a thoroughly interesting and instructive demonstrative lecture on acoustics.

Thirty formal committee meetings were held during the five interest-packed days of this Annual Meeting, while 38 papers were presented at the 17 technical sessions. So comprehensive and so detailed was the work done by the multitude of committees that even a summary of the results cannot be available now.

S.A.E. Standards Committee Meeting

The regular meeting of the Standards Committee was held Thursday. C. W. Spicer presided.

Outstanding reports were those of the Iron and Steel Division, which included a complete revision of the S.A.E. steel compositions and physical property charts, and of the Screw Threads Division, bringing the S.A.E. Screw Threads Standard up to date and introducing standard 8, 12 and 16 series of pitches. New specifications reported to the Standards Committee were Automotive Cast Irons, a Motor Vehicle Lubrication Data Form, Outboard Motorboat Transoms, Oval Dimensions for Tanks for Gasoline Tank Trucks and a uniform specification for the fillets under the heads of finished screws and bolts. A new American Standard for Drill Jig Bushings was also approved by the Society as a sponsor for this project.

Twelve Divisions reported on 17 subjects, of which ten were revisions in present S.A.E. Standards, six were new standards submitted for adoption by the Society and one report, that of the Tire and Rim Division, was the cancellation of the present tire, rim and tire valve specifications.

Several of the subjects reported as revisions were approved subject to a final check by the respective divisions submitting them, but it is anticipated that most of these will be completed in time to include the revised specifications in the complete 1935 edition of the S.A.E. HANDBOOK that is being prepared.

The action taken by the Standards Committee on the subjects reported was referred by Chairman Spicer to the Council immediately following the Standards Committee meeting, and were approved for adoption by the Society and for publication.

With a record of two of the Society's most successful years from the standpoint of meetings to look back on, Alex Taub turned over to A. L. Beall, the chairmanship of the National Meetings Committee. Mr. Beall has been vice-chairman during 1934.

Win Double Award for Aircraft Paper

Two "firsts" were established by the award of the Wright Brothers and the Manly Memorial Medals for 1934 to R. B. Beisel, A. L. MacClain and F. M. Thomas for a paper on "The Cowling and Cooling of Radial Air-Cooled Aircraft Engines". The paper, which was published in the May, 1934, issue of the S.A.E. JOURNAL, was presented at the 1934 Annual Meeting of the Society in Detroit. By receiving both the Wright and Manly medals it becomes the first paper to be so honored since the establishment of these awards "for meritorious contribution to aeronautic engineering" and the first paper of joint authorship to receive either of the awards.

R. B. Beisel
Chance Vought Corp.

A. L. MacClain
Pratt & Whitney Aircraft Co.

F. M. Thomas
United Aircraft Corp.

News of the Technical Sessions

Digests of all papers presented at this Annual Meeting appear on pages 33 to 39 of this issue. In the March issue there will appear in similar form comprehensive digests of the discussion which took place at each of the sessions.

At the technical as well as the more general sessions, however, many interesting ideas were developed on a variety of topics, the high points of which combine to form a general running picture of the events of the five days.

Transportation and Maintenance Session

At the Transportation and Maintenance Session with which the meeting opened on Monday morning discussion centered largely on the paper by T. L. Preble, Tide Water Oil Co. So active was the debate that Chairman L. V. Newton finally had to close the session without its having been completed. Mr. Preble added to his formal paper information as to *when*, as well as *how* to buy a truck. Among the many important points made was that "of the necessity of furnishing the seller with a clear cut and definite statement of conditions to be met".

"Normally I believe standardization upon one make to be unsound practice from the operator's viewpoint," Mr. Preble said, but added that "a complete 'open door' policy is unsound. The buyer," he added, "should become fully alert to the effect of faster average speeds and should avoid trucks which will 'nickel and dime you to death' by constantly breaking down on the road . . . or needing attention through failure of ten-cent parts or accessories."

L. E. DuBey presented the first paper of the session on "How to Finish a Truck" as co-author with P. R. Croll. He said that "no simple answer will ever finally dispose of this question. Honest differences of opinion encourage new developments of better materials and methods." He added that "improved service to fleet owners would result especially from closer exchange of ideas between body builders and refinishing shops" and concluded his paper by suggesting that "a permanent place be given on the annual meeting program—to the subject of vehicle finishing." Chairman Newton said it should be possible to do a satisfactory job of truck finishing within two days, presumably referring to refinishing in particular.

T. C. Smith, in discussion of the Preble paper, indicated that the omission of only one significant item in a truck specification might lead to unsatisfactory results or failure to do the job required and mentioned the effect of legislation on required minimum speed on grades. Leo Huff urging the desirability of standardization on one make, took issue with Mr. Preble and asked for the author's reasons for his opposite view. Mr. Preble answered that a single make puts the purchaser in a poor trading position and is likely to make the manufacturer less inclined to satisfy the operator.

F. C. Horner expressed agreement with Mr. Preble about the value of performance records and the desirability of studying the users' problems. He asked how a preferred list should be made up and said that he considered the principle of reciprocity in purchasing logical. Mr. Preble answered by saying that several items such as availability of service, quality of product and data on such items as brake areas and the like are properly considered in making up a preferred list. A. J. Scaife pointed out some of the difficulties encountered in requirements on grade-climbing ability, stating that, regardless of gear ratios and other factors, a certain power must be available to attain a given speed on a given grade with a given gross load.

E. C. Wood said that, on the Pacific Coast, it had been found desirable to test trucks under actual service conditions in determining their ability to do the work required. He added that the engineers on the Coast feel the need for exchange of information beyond that now afforded through Society publications. Preventive maintenance has been practiced on the Coast for many years and has proved its worth, he said.

J. G. Moxey mentioned several items on which he said that trucks are judged by his company, one of these being the gallons per mile per gallon of product delivered to customers by the vehicle. He said that during daylight-saving periods it is often possible to use a truck 18 hours a day with three shifts of drivers, under N.R.A. rules, but in the winter, when less fuel is sold, only a two-shift basis is feasible or needed. J. M. Orr mentioned troubles encountered with lacquer finishes and said that his company is experimenting with synthetic finishes but has no final results as yet.

M. C. Horine, among others, complimented Mr. Preble highly on his paper. He agreed, he said, that the operator

should not try to design the vehicle but should be specific as to his requirements and leave the manufacturer to decide how they should be met.

J. M. Orr, acting as chairman of the Transportation and Maintenance Luncheon on Monday, complimented F. L. Faulkner on the excellent results achieved by his summer meeting paper and said that the second part, considered at this meeting, would undoubtedly receive similar commendation. This proved to be true, judging by the discussion which followed presentation of the paper, which dealt with "Motor Vehicle Design from the Operation and Maintenance Standpoint". In criticising electrical equipment, the author said it would appear logical from the operators' viewpoint to specify "what can be expected from the battery at zero deg. fahr. for a period of five minutes to three volts" as this "is about the minimum factor of safety that a fleet operator should have." Several other items of electrical equipment which give trouble were cited after which truck ratings were considered. Mr. Faulkner declared that "little if any serious effort is being made to develop a rating" and then proceeded to suggest a very specific rating which avoided the theoretical factors that have led to nothing of value in the past.

B. B. Bachman in his discussion admitted that the truck rating committee had gotten nowhere but questioned whether the author's suggestions could be brought into harmony with differing designs dictated by differing policies on the part of various manufacturers. Nevertheless he said that he valued the data submitted and expected to make good use of it. E. W. Lager stated that a logical truck rating is difficult to evolve but that the foundation had now been laid for a definite rating and should be followed through. Leo Huff said he would like to hear other views from truck manufacturers and criticised them for failure to find out what the operators really need.

M. C. Horine declared that the facts brought out by Mr. Faulkner had clearly demonstrated the value of the T & M Activity and that rarely had anything so constructive been evolved. He questioned, however, whether the studies of maximum, minimum and average factors presented are the best criteria. He suggested that certain of the data should be developed further to indicate what is wanted rather than what should be avoided. He pointed out that minimum price and maximum durability cannot go together.

T. C. Smith declared that truck ability and load-carrying capacity may be changed by different options in engines and that comparisons based on chassis weight less engine weight may well give food for thought. Pierre Schon said Mr. Faulkner's analyses had made engineers realize certain mistakes in design. He said, however, that a standard for all operations is not feasible and that there must always be building for specialized applications, involving such items as electrical equipment, clutch area variations and the like. He pointed out that the author had recognized in his paper that several of the items he had criticised in his summer meeting paper have been corrected, showing that the criticisms had been heeded, and expressed the belief that similar results will continue.

L. V. Newton voiced appreciation of the fact that truck manufacturers are trying to cooperate and believes they will wish to consider the further recommendations made in Mr. Faulkner's paper.

Closing the discussion, Mr. Faulkner said that he appreciates the spirit of cooperation. He said frankly that the operator is trying to secure a maximum for the lowest cost. He well understands the pertinence of Mr. Horine's point, however, to the effect that it is not fair to overlook quality. The superiority of a given product in this respect may well be left to the sales force. It is true that many small matters that have given trouble are being cleared up, but there is still need for further study of details that are sometimes left to subordinates who do not have adequate experience.

Tire Problems at Truck Session

Results of experiments with the use of rubber for automobile springs were among the novel facts brought out by Curt Saurer, Firestone Tire & Rubber Co., in his talk about "Engineering Uses of Rubber" at the Truck, Bus and Railcar Session on Monday afternoon. More than 100 engineers heard Mr. Saurer tell of successful experiments with rubber insulated wheels on railcars and state that "there is no reason why some of the principles developed on these wheels could not be adapted to automobiles."

A. K. Brumbaugh, vice-president of the Truck, Bus and Railcar Activity for 1934, presided at this session.

F. L. Haushalter of Goodrich, E. G. Kimmich of Goodyear, and Walter Keys of U. S. Rubber Co. were among the leading tire engineers who, in discussion, amplified some of the points made by Mr. Saurer or brought out additional phases of the rubber utilization problem.

Motor supports in the future must have a decidedly slower vibration time, Mr. Saurer said, and also a slower dampening action. He pointed out also that many experiments are being carried on in combinations of rubberized materials for seat cushions, arm rests or panel insulation. "In England," he said, "sponge rubber seat cushions of certain designs are commonly used. We have experimented in the United States with similar cushions, but have not been able to reduce their weight successfully down to that of present spring cushions. This has been one of the most severe handicaps in the progress of this material, as probably the price and the performance are equal, over advantages still inherent in the steel spring cushion."

Rubber fenders for passenger cars are economically unsound, according to Mr. Saurer, and would add to the weight of the car. Fender liners, on the other hand, he believes will have to be included as a standard necessity on higher-priced cars.

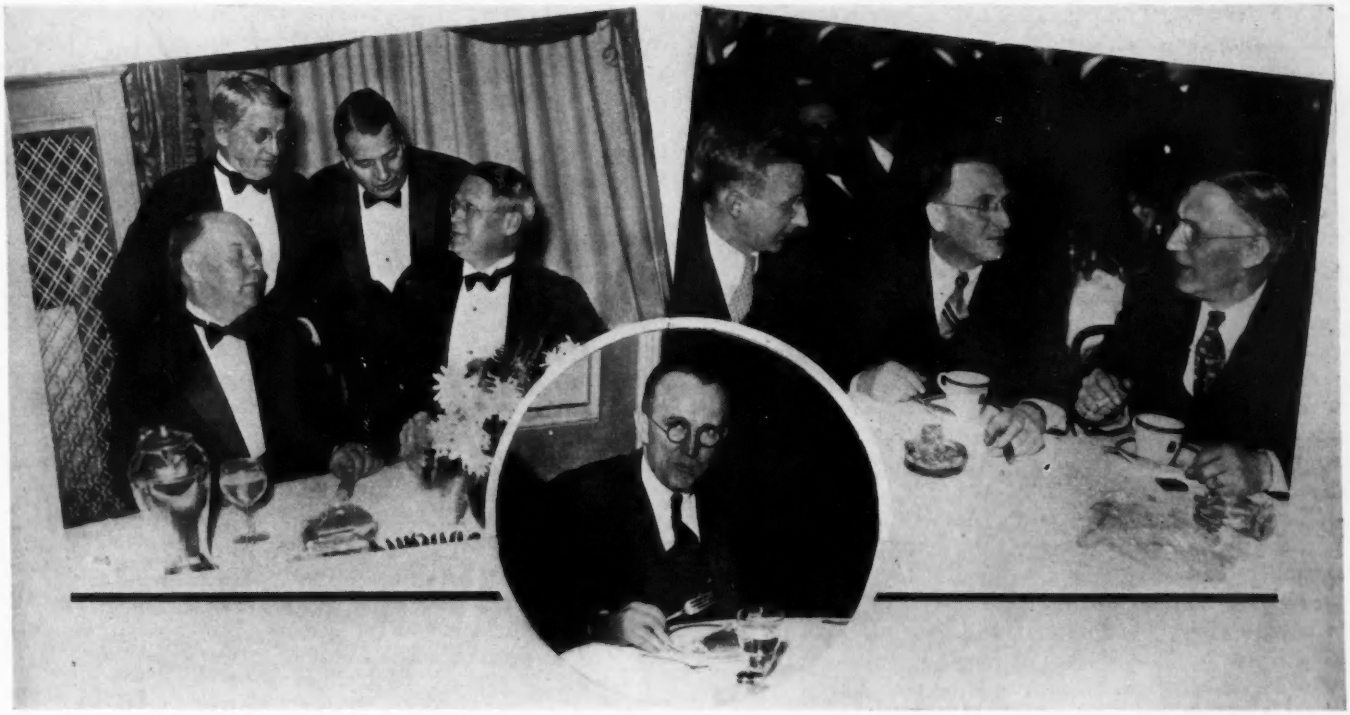
Mr. Saurer got the combined approval of the other rubber engineers who entered into the discussion when he stated that "Most of the devices we put into automobiles are afterthoughts and almost invariably we are cramped for space to put in a suitable product from the rubber manufacturer's standpoint."

Discussing the widespread automotive uses to which rubber may be put, Mr. Saurer summed up one phase of his discussion by saying:

"Our limitations are imposed only by the efficiency and the thermal conductivity of the rubber part. It is impossible to state in definite figures just what heat any compound will withstand, since working conditions are not standard. Every rubber part must be designed for the job it is to do."

The rubber engineers seemed to agree in discussion that 160 deg. fahr. is the practical working temperature limitation of rubber, if the material is to have any life left after two or three years.

M. C. Horine asked about the relative strength of the experimental rubber springs as compared with steel springs,



Three past-presidents talk with General Manager John A. C. Warner. Col. H. W. Alden, standing beside Mr. Warner, has been chosen chairman of the recently-established Past-Presidents' Advisory Committee. A. J. Scaife (seated left) was President in 1932. J. H. Hunt, (seated right) is chairman of the Publication Committee.

Harold Nutt, past-chairman of the Chicago Section and chairman of the National Sections Committee in 1934, pauses to cast an inquiring eye on the camera man.

Alex Taub has just completed two years as chairman of the National Meetings Committee. He sits with two fellow General Motors men—Al Hazard at the left of the picture and W. A. Hoult at the right—talking over the record-breaking attendance figures of the 30th Anniversary Annual Meeting.

pointing out that the use of rubber becomes less attractive as the weight of the vehicle increases. Mr. Saurer replied that the spring used in the experiments which he had discussed weighed about 6½ lb. including the attachment parts, but that his company had developed a new spring which weighs only about 3 lb. and which will support a load of 1800 lb.

Answering a question from Mr. Horine as to why rubber bushings cannot be used in water pumps, Mr. Haushalter said that the pressures and temperatures are too high and that various types of radiator solutions have a deleterious effect on rubber.

Herbert Chase mentioned use by one car manufacturer of a molded phenolic-resin covering over rubber steering wheels, and asked if this was done chiefly because of the color or finish thus obtainable. S. M. Cadwell of U. S. Tire Co., Inc., answered that this is the case.

Aircraft-Engine Sessions

Tuesday morning's Aircraft-Engine Session had to do largely with the effects of fuel and oil on aircraft-engine performance, Robert Insley presided and the session was well attended. S. D. Heron presented the opening paper entitled "Aircraft and Aircraft-Engine Performance as Influenced by Engine Oil." After describing results secured with different oils as based on data secured from U. S. Army Air Corps tests he concluded, "Aircraft engines are being subjected to increasingly high duty and are requiring better oils for the purpose. New methods of refining are rendering possible the production of oils which are greatly improved in a variety of their qualities, but in the present state of knowledge the use of such oils in aircraft engines involves some uncertainty as regards stability."

H. C. Dickinson, A. L. Beall, J. P. Stewart and Arthur Nutt were among those who took part in the discussion. Much of this had to do with the dangers of using low-viscosity oils to facilitate starting in cold weather. It was pointed out that such oils are likely to result in rapid cylinder wear.

The paper by Squadron Leader A. Ferrier of the Royal Canadian Air Force dealt with "The Winter Operation of Aero Engines" and pointed out the many difficulties encountered in Canada, especially in starting in cold weather when very low temperatures prevail. "The immediate problem," he said, "is to get the technique of cold motor starting into line with the progress of lubrication. . . . When that is achieved it is proposed to aim at a figure of 40 deg. fahr. below zero —there is little doubt that there will soon be available a 53-second oil with a remarkably good viscosity index . . ."

In discussion, Dr. Dickinson said that a gasoline which will be sufficiently volatile to enable starting at 40 deg. fahr. below zero is possible but it might result in trouble from vapor lock after the engine warms to normal operating temperature. Other speakers mentioned difficulties with valves which stick open—presumably because of cold lubricant—as another cause of hard starting. It is believed, one speaker said, that the use of pressure lubrication of valves by oil may prevent this trouble. Another speaker made it clear that trouble with cold weather starting is not confined to Canada and mentioned one case in which it required more than two hours to get the engine in a certain plane started for a particular

trip which required only one and one-quarter hours of flying.

In closing the discussion Mr. Ferrier said that his experience did not include engines of high specific output, but that excessive wear with low-viscosity oils had not been encountered. He attributed wear more to corrosion after stopping than to the effects of running.

Arthur Nutt made a progress report as chairman of the C.F.R. Aviation Gasoline Detonation Subcommittee in which he stated that "the minimum engine test program may be regarded as 85 per cent complete. It appears possible," he continued, "to complete the test work by April 1 . . . and it should be possible by the time of the Summer Meeting to have available a complete analysis of the test results."

Development work on spark-plugs having higher heat-ranges than any now commercially available, and fuel injection for aircraft engines instead of carburetors, were the two feature topics of the Aircraft Engine Session Tuesday afternoon.

With Opie Chenoweth, U. S. Army Air Corps, in the chair, the first subject was covered by M. F. Peters, National Bureau of Standards, who presented a paper entitled "An Investigation of Mica Spark-Plugs," prepared jointly by Mr. Peters with John F. Boston, Naval Aircraft Factory, and H. K. King, National Bureau of Standards.

The objective of the investigation was to develop a plug which would be less susceptible to both pre-ignition and fouling. A major conclusion drawn was that to keep the plug hot enough to prevent fouling it is necessary to keep the top cool. This seeming inconsistency is explainable by the fact that to achieve the desired result a much higher temperature gradient from bottom to top of the plug is necessary to keep from ruining the cable insulation. As Mr. Peters said, a cable can easily be ruined by permitting too much leakage of current also into the shield of the plug in an aircraft-engine installation.

In discussion a letter from Earl A. Keeler, Defiance Spark Plug Co., stated that it isn't necessary today to provide "hot" plugs to keep from fouling. Mr. Keeler also described a test method for checking carbon deposit formation on a spark plug. Briefly this consists of connecting the plug to the secondary of a transformer and measuring the amount of carbon deposited by the conductivity of the plug.

Of major commercial interest was the first public revelation of details of the work which the Army Air Corps has been secretly carrying on in connection with fuel injection for airplane engines. This work, primarily started to improve maneuverability of airplanes as compared to carburetor equipped engines, has now progressed to a point where it is tentatively planned to specify fuel injection for all engines bought by the Army for single engined planes after July first of this year.

Although the work was started purely from tactical maneuverability considerations, J. F. Campbell, United States Air Corps, in the paper in question, "Fuel Injection as Applied to Aircraft Engines by United States Army Air Corps", stated that engines so equipped had shown marked improvement in fuel consumption and power output compared with the same or similar engines carburetor equipped.

In discussion, Mr. Chandler stated that an important advantage of the use of fuel injection was that it resulted in some stratification of the charge, permitting part load operations at higher compression ratios. In answer to a question by F. C. Mock, Bendix Products Corp., Mr. Campbell stated that the engines used had had the conventional compression ratios of 5.25 and 6.0 to one with maximum boost pressure of 7½ in. of mercury. With this a gain of 80 hp. was experienced with engines normally developing around 425 hp. and 585 hp. or thereabouts.

Most of this work was carried on with standard 87 octane fuels, Mr. Campbell said in answer to a question of Alan Ferrier of the Canadian Air Service. He said, however, that they had found it possible to operate with alcohol-water and gasoline-water mixtures (5 to 6 per cent of water), with a resultant decrease in detonation characteristics, improved cooling and no reduction in horsepower.

In answer to a question by A. H. Kipfer of American Air Lines, Mr. Campbell stated that engine acceleration was eminently satisfactory with the fuel-injection system, and better than with carburetors if the system is properly phased (timed).

Requested by Mr. Chandler to say something about the wear characteristics of sliding parts lubricated in the system only by the fuel used, Mr. Campbell said that in some cases the highly-loaded sliding surfaces actually become too hot to touch, but that apparently even under these conditions the gasoline does lubricate the surfaces. Mr. Campbell stated that no case of seizure had been recorded and that in the last few years at least no unsatisfactory surface wear conditions had been experienced.

During the session, H. K. Cummings, National Bureau of Standards, also gave a few preliminary details as to two Italian installations for "high altitude" testing of aircraft engines, one at the Isotta-Fraschini plant, the other at the Fiat plant. The first of these is of the double branch closed wind-tunnel type, capable of duplicating 10 km. altitudes in testing water-cooled engines up to 800 hp.

The Fiat installation, is capable of testing 1000 hp. water-cooled engines "up to" 5 km., and 500 hp. engines up to 10 km. Air-cooled engines up to 500 hp. can also be tested on this equipment up to 5 km. The refrigerating equipment for cooling is of course built into the closed tunnels in either case.

Planography at Body Session

Supplementing his paper of January, 1934, in which he introduced Planography to the industry, Edgard C. De Smet, body designer, Hudson Motor Car Co., as the chief speaker at the Body Session on Tuesday evening offered a new planographic theory "as a logical and scientific solution for all irregular surface problems."

Adoption of the methods which he advocates, Mr. De Smet said among other things, "would permit cancelling the present procedure of taking information off the model."

"If the model had been built and altered and refined from drawings," Mr. De Smet stated, "we would find that whenever final approval is given, there would be no need for making numerous templates, sections or slices. Our records would give us immediately all necessary data regarding the master lines, and we would be able to proceed with the surface draft or 'planograph' at once."

Among the secondary advantages, of the planographic system, Mr. De Smet mentioned the following:

"1. The desirability of adopting a uniform standardized procedure throughout the entire organization, for all surface layouts, including sheet metal parts as well as bodies, to replace the various disconnected, inconsistent and incomplete methods now in use.

"2. Concentration of all surface layout work in one separate department, by relieving the construction men of all

such problems and confining same to the responsibility of trained specialists.

"3. The accuracy and dependability of planographs would permit the release of auxiliary information to other departments for the designing of dies, tools and fixtures, at an earlier date than is possible under the present system.

"4. Correctly proportioned surfaces mean simpler draw dies, a minimum of adjustment of the presses, an easier and better flow of the metal and, consequently, a greater uniformity in thickness of the finished panels.

"5. The perfection of surface attained and the scientific features of the principles involved should be worthy of the attention of the public at large, and would, consequently, fully justify their capitalization by the sales and advertising departments."

Chairman at this session was John Votypka, vice-president of the Society for body engineering in 1934.

Passenger-Car Suspension Session

Expressions of strong approbation came from both tire and passenger-car engineers for R. D. Evans's talk at the Suspension Session on the relation of tires to the problem of driving an automobile, which "consists in maintaining appropriate control over a somewhat complex and ever changing system of forces". (Mr. Evans's paper is printed on pages 41 to 49 of this issue.) K. D. Smith of Goodrich suggested that it might possibly be desirable some time in the future to have different tires for the front and rear of cars, the front tires being built to have the best possible "cornering" characteristics. R. W. Brown of Firestone complimented Mr. Evans for getting down to real measurements on tire effects, emphasizing the fact that only through such measurements is it possible to effect the best compromise of the conflicting factors involved in the tire-vehicle problem.

Lee Oldfield questioned the safety of a car in which the engine is moved too far forward, saying that race drivers care little for a rear-end skid when the track is clear, but greatly fear front-end skids. E. S. Hall also expressed the opinion that too much weight too far up front might be dangerous from the skid angle.

Elliott G. Reid, Stanford University, in his paper entitled "Farewell to the Horseless Carriage", voiced the opinion that, despite its luxurious modernization, the carriage still is with us in the present-day automobile. "It retains its century-old external crudeness", the California educator said.

Mr. Reid definitely opposed the widely-made statement that streamlining for air resistance, at all but very high driving speeds, is either inconsequential or not materially reducible by practical methods. He claimed also that motor car air resistance is the analogue of airplane parasite drag, adding that "the remarkable reductions of the latter which have been effected through recent aerodynamic research make it seem absurd to think that similar developments are not to be expected in the automobile field.

Prof. W. E. Lay, University of Michigan, expressed pleasure at finding through Mr. Reid's paper that "somebody still is working on this subject of streamlining". Much progress has been made, Prof. Lay said, but the limit is far from having been reached.

W. R. Griswold, Packard Motor Car Co., who presided at this session, was of the opinion that the ultimate value of streamlining will be determined by (1) style demands of the public, (2) the difficulty of changing people's habits—most people still like to sit behind a long hood, rather than up front as they would in a rear-engined, fully streamlined car, and (3) by gradual experience—every worthwhile development endures and becomes a part of standard design practice if it is fundamentally sound.

Four Aces from the Pacific Coast

Each of the four Pacific Coast Sections was represented at this 30th Anniversary Annual Meeting—and no four men were more prominent in the activities nor more welcome. E. C. Wood (left) comes from Northern California; H. A. Reinhart, from Northwest; F. C. Patton from Southern California; and Harley W. Drake from Oregon.

Frank Watts, vice-president of engineering for Hupmobile, puts his hand on F. C. Thompson's back as the latter shakes hands with William Mueller. F. B. Willis, Bendix sales ace, looks on from the right of the picture.

A Hyatt group gets into the foreground, with chief engineer O. W. Young (left) getting a better view of whatever it is than H. K. Porter (center). Jack Roach (right) doesn't seem to care.

Dave Anderson, chief engineer of Bohn Aluminum and Meade Moore, chief engineer of Nash looked pleased about a miniature baseball bat the latter holds in his hand.

E. S. Hall disagreed with Mr. Griswold on all three counts. Lee Oldfield backed Mr. Hall's statement with the remark that "We will never get anywhere as long as our attitude is negative".

Following a brief introduction by J. H. Shoemaker, commissioner, Leaf Spring Institute, Karl K. Probst, consulting engineer of that organization, described the advantages of the leaf-spring type of independent wheel suspension which has been developed by the Leaf Spring Institute, pointing out that the eventual decision as regards leaf vs. coil spring types probably will lie "in the comparative durability, weight and cost as compared to the relative advantages."

The work done by the Leaf Spring Institute, Mr. Probst said, led his group to a tubular backbone frame design which, he believes, is essential for soft suspension setups, because it increases the torsional rigidity from 1½ to 5 times and reduces cost and weight from 20 to 30 per cent.

B. P. Sergayeff presented calculations to show that the saving in unsprung weight through use of independent wheel suspension is not very great, and expressed the view that the most favorable result brought about by independent springing is the divorcing of springing from the steering of the front wheels.

Diesel-Engine Sessions

Two papers were read at the Diesel-Engine Session on Wednesday morning. The room was well filled and time for discussion had to be limited. H. D. Hill was chairman.

Alfred T. Gregory presented the first paper entitled "Cylinder Events Studied in the Logarithmic Diagram". "Such a diagram," he said, "lends itself peculiarly to the study of cylinder conditions and to the quick determination of the changes taking place." He then proceeded to show how the diagram is constructed and used. He indicated that by its use heat input, losses resulting from unburned fuel, power output, mean effective pressure and heat in the exhaust gases, among other items, can be determined.

Prof. L. C. Lichty took a leading part in the discussion and pointed out how the methods described might lead to certain errors, especially through "dangerous" extrapolation and through failure to consider changes in the value of the exponent during adiabatic expansion. He also questioned

whether the use made of Ricardo's curves showing the effect of dissociation led to correct results. E. S. Dennison agreed with Prof. Lichty, especially as to the degree of dissociation, which is not known.

In reply, Mr. Gregory said that the whole idea was to secure results quickly. He admitted that the expansion line is curved rather than straight but indicated that, by using an average value for the exponent, the results secured are satisfactory, at least within certain limits. In reply to a criticism of E. T. Vincent that combustion is not complete in gasoline engines when the exhaust valves open, whereas the diagrams given showed otherwise, the author said that the flame seen at the exhaust is probably not an indication of incomplete combustion but is probably caused by incandescent carbon. He said that he realized the desirability of adding cards from solid-injection engines but did not have them in hand when the paper was prepared.

In the second paper, E. S. Dennison presented what he termed "A Rational Basis for Comparing Diesel-Engine Performance." He indicated that, although all Diesel engines have certain principles in common, their dissimilarity in design "has hindered attempts to place various performances on a comparable basis. Limitations must attend any effort to place performances on a universal common basis," he added, "but there seems to be room for a more general statement of engine characteristics than is usually made." He then described a procedure which "has proved useful as a routine analysis of test results," and which he called "simple . . . and easily applied to any type or size" of engine.

Very little time was afforded for discussion of this paper, but Harte Cooke, E. T. Vincent and others, made brief comments.

With F. M. Young in the chair, the Diesel-Engine Session (Wednesday afternoon) was opened with a report of progress of the Volunteer Group for Compression Ignition Fuel Research, which was presented by the chairman of the committee, T. B. Rendel. The Volunteer Group was "banded together in 1933 to carry out some cooperative experiments on the most promising methods of measuring ignition quality," Mr. Rendel explained. He added, "The experimental work naturally falls into subdivisions: 1—Perfecting the test engine and technique; 2—Determining a suitable scale for expressing ignition quality; 3—Effect of various engine factors on relative rating of different fuels; 4—Physical and chemical methods of rating; 5—Field testing and correlating service results with laboratory tests. Already a fair amount of work has been done under the first two heads. About ten of the new type engines are now in operation in the laboratories of members." He described the new Diesel head provided for the C.F.R. engine but made it clear that the work with it has not yet progressed far enough to report specific results.

In discussion, Harte Cooke said that the aim of the group should be to fit the fuel to the engines available, both small and large, with due regard to the higher temperatures attained in the large sizes. C. L. Cummins spoke of having had 25 samples of fuel oil submitted for use in his Diesel racing engine and said he had found no important differences between them; also that low cost and cleanliness are desirable factors in a Diesel fuel. Dr. A. E. Becker said that Mr. Cummins seems to think that "any old fuel" will do but that Diesel engine manufacturers generally desire a rather rigid specification. He feels that a happy medium between these extremes may well be found. As compression ratios are raised in Diesel engines, he added, a broader range of fuel becomes available, which is just the reverse of the condition with gasoline engines. Before a classification can be made for Diesel fuels, more field information as to what is satisfactory in respect to various qualities is required.

C. M. Larson stated that distribution difficulties with Diesel fuels have arisen already, owing in part to the use of Diesel engines in road-building work. He predicted that two types of fuel probably will be required, one for large slow-speed engines and another for the higher-speed type. Viscosity is another matter which has given trouble, especially during cold weather. There may be some tendency to adopt a furnace oil which can be made available as a Diesel fuel. One difficulty encountered is with fine grit which causes rapid wear in pumps. H. D. Hill said that Diesel fuel specifications are of great importance, both to the engine manufacturer and to the user. Without them it is difficult to secure satisfactory operation, because neither the engine men nor the oil supplier knows what is wanted. Headway is now being made and should bring cooperation from all sides.

In closing the discussion Mr. Rendel reiterated that information as to field experience is badly needed; the real point the group is striving for is to secure information which will permit of giving a satisfactory fuel without too rigid a specification. Probably a light-viscosity and clean fuel will be among the requirements. Ignition quality is not the only requirement by any means.

C. R. Alden presented the second paper: "Design and Development of Injection Apparatus for High-Speed Diesels". He pointed out disadvantages of certain types of injection pumps, named sixteen requirements which a pump should incorporate, and then described a new form of pump which his company has developed. He showed how this meets desired conditions.

Most of the discussion consisted of questions, although E. T. Vincent expressed a preference for a pump which could be adjusted on the job and would not have to be returned to the manufacturer for servicing. Another speaker stated that there is need for a pump "which will not cost more than a small engine itself". There is great need for an inexpensive pump, he indicated.

Responding to questions about details of construction, Mr. Alden indicated that, hydraulically, the pump is much the same as others, though entirely different mechanically. Certain types of delivery, such as a tapering off near the end, may not be obtainable but different velocities of discharge can be secured. The rotor is ⅜ in. in diameter and speeds up to at least 2500 r.p.m. of the crankshaft are feasible.

Private Airplane Needs Analyzed

In an exhaustive analysis of "Sales and Technical Problems of Private Commercial Airplanes", Peter Altman, consulting engineer, Stinson Aircraft Corp., brought out many interesting facts among which were that: there has been a definite trend away from the open cockpit type of monoplane or biplane for commercial use; the production of monoplanes now is well ahead of biplanes; and there is an opportunity to develop a good export business, particularly with countries south of the equator.

Mr. Altman's was one of the three papers at the Privately-Owned Airplane Session held Wednesday afternoon with T. P. Wright presiding. F. S. Spring, Hudson Motor Car Co., talked on "Are We Giving the Average Private Operator the Airplane Most Suitable to His Needs?" and J. H. Geisse,

Department of Commerce, on "Air Transportation Equipment for the Private Owner."

Citing the probable needs and desires of the private airplane owner, Mr. Spring said among other things that:

"It is reasonable to assume that the private operator will in time encounter nearly all of the flying conditions that the pilots of passenger transports encounter. He will meet such conditions over strange territory and he will not, by training, be so well equipped to meet them; so his equipment must be adequate and his plane must be capable of being operated under these conditions with less skill than the transport."

Mr. Spring concluded with the following vision:

"I seem to be able to see myself commuting from the country, landing in a vacant lot, folding my rotors and driving my vehicle away just as I would a car."

Pointing out that an outlay of about $500 is necessary for a pilot to get enough flying time to fulfill the Government requirement of 50 hours of solo time before he can take up his friends, Mr. Geisse stated, "When we talk of bringing cost levels down comparable to automobiles, it is foolish to start with a training charge which is in itself equal to the cost of an automobile. Furthermore, material reductions in costs will require quantity production and, unless either private capital or the Government is willing to take the risk of financing production in advance of sales, then sales must lead production and cost reductions will have to wait on sales increases."

The airplane suitable for private flying, according to Mr. Geisse must be as simple to fly and as safe as present knowledge will permit us to produce. "The officials of the Bureau of Air Commerce," Mr. Geisse concluded, "have a responsibility to 125,000,000 people of which only a fraction of one per cent are in the aircraft industry. Our goal is flying equipment suitable for the 125,000,000."

Aircraft Transport Operations

If the two papers presented at Wednesday night's Aircraft Transportation session, with P. A. Wright, assistant to president, United Air Lines, as chairman, could be taken as a criterion it might easily be assumed that aircraft manufacturers and transport operators see pretty well eye to eye in many respects as to requirements for transport airplanes.

The discussion, however, emphasized that such was certainly not the case and that even among transport operators as a group, or manufacturers as a group, differences of opinion exist. The topic which produced the most heated argument was that of three-engined vs. either two- or four-engined planes, William Littlewood, chief engineer, of American Airlines, Inc., having taken a stand for the latter in his paper entitled "Operating Requirements for Transport Airplanes."

Additional points brought out by Mr. Littlewood included a prediction that automatic control for propellers and automatic synchronization of engines were probabilities for the near future; a statement that time lost in operation by servicing and repair requirements overshadows first cost of equipment; a request for development of higher voltage A.C. electrical equipment to reduce weight; a hope that further engine development may permit use of lower grade fuels; and a demand for airplanes having more adequate passenger accommodations for sleeper service.

The manufacturers' point of view was presented by J. L. Atwood, General Aviation Corp., who had assisted J. H. Kindelberger in preparing their paper entitled "Designer's and Manufacturer's Viewpoint on Requirements for Aircraft Intended for Airline Operation."

Among the many requirements which have been neglected, according to the authors, are: reversible seats similar to railroad practice, heating and ventilation and reduction of noise transmission particularly through the windows of the cabin, acting as diaphragms. In connection with the growing favor of low-wing monoplanes, they stated that visibility for passengers, poor in this type of plane at best, is not an important consideration.

Mr. Atwood added that the next important step in transport design will be a bi-motored monoplane of from 30,000 to 40,000 lb. gross weight, powered with two motors of from 1000 hp. to 1500 hp. each, with sealed and supercharged cabin, for cruising at altitudes of from 35,000 to 40,000 ft. at operating speeds of from 275 to 300 m.p.h., making possible transcontinental flights in from nine to ten hours.

In discussion, R. W. Ayer, Stinson Aircraft Corp., expressed the belief that propeller disc area is vitally important in connection with take-off time and distance, recalling two similar planes, of which one with a higher power-loading had a shorter take-off time than the other, the only explanation being that it had a larger disc area.

Some discussion also was caused by Mr. Littlewood's statement regarding the importance of wing flaps for deceleration rates on the ground. Mr. Littlewood, questioned by Mr. Ayer on this point, explained that he was not thinking of flaps as a substitute for brakes, but rather as an added advantage in decreasing loads on brakes, facilitating ground handling, etc.

Mr. Ayer also said that much can be learned by the aircraft industry from the automotive, and expressed his gratitude to automobile manufacturers for availability of experience on buses, trucks, etc. According to Mr. Ayer approximately 50 to 75 per cent of cost for such parts as starters, boosters, steam heating units, fuel pumps and gages, battery chargers, hydraulic brakes, etc., can be saved by cooperation with the automotive industry—with increased reliability for the parts in question.

Questioned by J. J. Curran, American Airlines, as to rumors of larger airplanes being in prospect, Mr. Littlewood stated that one manufacturer at present is working on a 48-passenger plane and that a 16-passenger day and night plane also is in the design stage. However, most manufacturers, he said, are waiting for larger engines before proceeding.

J. F. Corey, Stinson Aircraft, said that insufficient attention is being given at present to ground-time losses and that these largely offset many gains in cruising and top speeds.

Mr. Corey was one discusser who believed that three engines have an advantage over two or four. He claimed a lower power loss compared to payload with one engine out, for the tri-motor installation. Mr. Littlewood agreed that the theory was correct but said that it didn't work out in practice.

George D. Evans of Hammond Aircraft said, in connection with statements on time out for service, that in a study he made recently he had found that operators were utilizing their equipment on an average for only three to six hours out of the day. He wanted to know what operators were doing to boost the service time, estimating that almost 50 per cent of operating costs at present were fixed on a time basis irrespective of time of service per day.

Chairman Wright pointed out that peak loads are just as evident in aircraft operation as in other types of transporta-

(*Continued on page* 28)

Wide World

William B. Stout, President for 1935

On this and the three following pages appear photographs and brief biographies of members of the 1935 Council, including vice-presidents representing the activities. Each biography has been checked for accuracy of facts by the person it concerns.

Officers for 1935

WILLIAM B. STOUT still has a soft spot in his heart for the year 1910, during which he designed the Imp cycle car for the McIntyre Co. of Auburn, Ind. In those days he found time also to do technical writing for the *Chicago Tribune* and *Motor Age;* a brief editorial career of which his associates at that time are still relating anecdotes.

The skeleton of Mr. Stout's official biography makes an oft-told tale. His urge to build for the air bore fruit in 1916 when he became consulting engineer for the aircraft division of Packard, after a period as chief engineer for the Scripps-Booth Co., as technical advisor to the War Aircraft Board, engineer for the United Aircraft Engineering Corp., president, Stout Engineering Laboratories, Inc., president, Stout Metal Airplane Co., vice-president, Stout Metal Airplane Division, Ford Motor Co., and president, Stout Air Services, Inc., and again as president of the Stout Engineering Laboratories, Inc. He has strewn behind and before him crowded years of accomplishment in almost every vocational division of the automotive industry.

He began his S.A.E. career in 1917 as secretary of the Detroit Section. He has twice served as vice-president of the Society, in 1929, representing Aviation Engineering and in 1932, representing Aircraft Engineering. Many of the Society's committees have had the benefit of his constructive service and advice.

D. G. ROOS, president of the Society in 1934, continues on the Council as a past-president.

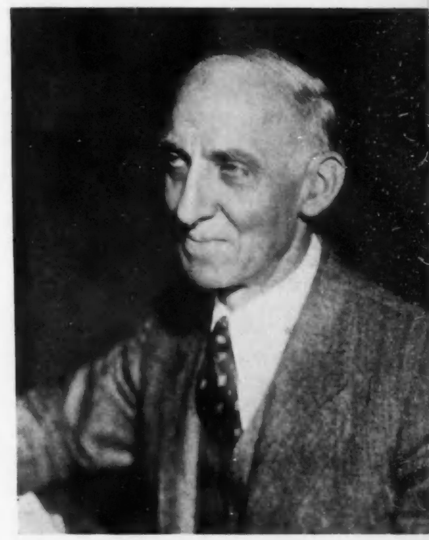
Mr. Roos joined Locomobile in 1912 as an assistant engineer in the experimental department. In the next 13 years he became successively: engineer, electrical engineer, chief of research and experiment, engineer, vice-president in charge of engineering and production, and in 1924, vice-president and chief engineer.

In 1925 he left Locomobile to become chief engineer of the Marmon Motor Car Co., Indianapolis, and in 1926 joined the Studebaker Corp., South Bend, Ind., as assistant chief engineer. From 1928 until the present, he has been chief engineer for Studebaker.

Delmar G. Roos

DR. H. C. DICKINSON, who continues with the Council as past-president, has been chief of the heat and power division of the National Bureau of Standards since 1922. Previously he was physicist in charge of powerplants research of the Bureau. From 1921 to 1923 he was manager of the research department of the Society. He was elected a member in 1918.

Dr. Dickinson is a member of several other technical societies, including the American Society of Mechanical Engineers, the American Society for Testing Materials, the Society of Refrigerating Engineers, the American Physical Society, the French Physical Society, and is a fellow of the American Association for the Advancement of Science.



Dr. H. C. Dickinson

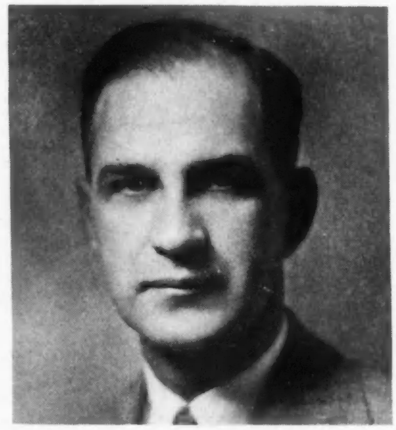
DAVID BEECROFT begins his third term as treasurer of the Society and ex-officio Council member. He is a past-president (1921) and has held many other important positions in the Society.

From 1904 to 1929 Mr. Beecroft was an increasingly prominent figure in the technical and business press of the automotive industry. Beginning as an assistant editor of *Motor Age*, he became director of all editorial activities for the Class Journal Co., which published a group of automotive magazines.

In 1929 Mr. Beecroft was elected a vice-president of the Bendix Corp., South Bend, Ind., and subsequently became manager of the New York office of the Bendix Aviation Corp.

David Beecroft

Councilors for 1935



J. M. Crawford

J. B. Fisher

FREDERICK C. HORNER, vice-president of the Society in 1930, representing Transportation and Maintenance Engineering, returns to the Council for the 1935-36 term. After several years in a construction business, he became in 1914, supervisor of motor-vehicles for the Watson Contracting Co., and his professional career since that time has been associated with the broader aspects of motor transportation. From 1922 until the present, he has been connected with the General Motors Corp., becoming assistant to vice-president in 1926.

Joining the Society in 1920, he was made a member of the Meetings Committee in 1928 and each year subsequently. In 1931 he became a member of the Military Motor Transport Advisory Committee and was the S.A.E. representative on the Motor-Vehicle Conference Committee. Other committees on which he has served as member or chairman include the Transportation and Maintenance Activity Committee in its various phases beginning with the old Transportation Activity Committee.

HARRY T. WOOLSON, who becomes a member of the Council for the 1935-36 term was chairman of the Detroit Section in 1934 and has served the Society as second vice-president (representing Marine Engineering). In addition to his membership in the S.A.E., Mr. Woolson also maintains membership in the American Society of Mechanical Engineers, the Society of Naval Architects and Marine Engineers and the Franklin Institute, which gives some indication of his professional versatility.

Up to 1914 he was designer and chief engineer for the Gas Engine and Power Co., and the C. L. Seabury Company Consolidated. Other companies which he served as engineer and chief engineer before his present connection as chief engineer, Chrysler Corp., include the Packard Motor Car Co., Studebaker Corp., Willys Corp., Zeder Motor Car Co., Zeder-Skelton-Breer Engineering Co., and the Maxwell Motor Corp.

He joined the Society in 1922 and four years later became a member of the Transmission Division of the Standards Committee. He served as a member of the Research Committee for four years and has previously been a Councilor of the Society in addition to holding the vice-presidency already mentioned.

AUSTIN M. WOLF, who joins the Council for 1935-1936, has been automotive consultant and director of standards for the State of New York for several years. His analysis of current trends in passenger-car design have been a leading feature in the January issue of the S.A.E. JOURNAL since 1932. Many meetings of the Society and its sections have benefited by his frequent and vigorous contributions of papers on various automotive subjects.

He joined the Society in 1911, at which time he was draftsman for the Interboro Rapid Transit Co., New York. He entered the automobile industry in 1912 with the Twombly Motors Corp., and in 1914 became designing engineer for the former General Vehicle Co. After serving as chief engineer for several companies he embarked in 1928 on a career as consulting engineer which he has continued to date.

He has served as secretary of the Metropolitan Section and twice been its chairman. The general Society committees on which he has served include Membership, Research, Publications, and the Motorcoach and Motor-Truck Activity.

J. M. CRAWFORD is a Councilor for the 1934-5 term, after serving in 1933 as vice-president representing the Passenger-Car Activity. He is chief engineer, Chevrolet Motor Co., Detroit, with which he has been connected since 1927, when he joined the company as assistant chief engineer.

Mr. Crawford began his automotive career as assistant engineer in charge of design for the American Motors Co. in 1907. Five years later he went with Chalmers as design engineer, and in 1917 became chief engineer of the Allen Motor Co. From 1922 to 1927 he was chief engineer of the Auburn Automobile Co. He became a member of the Society in 1913.

He was a member of the Passenger-Car Activity Committee (1930-1931) and of the Sections Committee in 1930.

ELEVEN years of work with industrial machines preceded James B. Fisher's entrance into the Waukesha Engine Co., Waukesha, Wis., with which he has been associated since 1915; from 1915 to 1923 as mechanical engineer, and since then as chief engineer. He was elected a member of the Society in 1917.

He became a member of the engine division of the Standards Committee in 1919, and has been vice-chairman of the same committee six times. All of his committee activities have been connected with the standardization work of the Society, including lubricants and motorcoaches.

Mr. Fisher was born at Johnstown, Ohio. For several years he worked for the American Steel Foundries and the Alliance Machine Co. of Alliance, Ohio. In 1909 he became mechanical engineer for the Federal Bridge Co., Waukesha, Wis.

Since that time his professional activity has been for Waukesha organizations, and he has been affiliated with the Milwaukee Section in his S.A.E. connections. He will serve on the 1935 Council.

F. C. Horner

H. T. Woolson

Austin M. Wolf

J. F. Winchester

J. F. WINCHESTER, manager, automotive department, Standard Oil Co. of N. J., first became a member of the Council in 1926. In 1933 he was vice-president representing the Transportation and Maintenance Activity, and served on eight important committees of the Society, including the two advisory committees cooperating with the U. S. Army.

In his connection with the Society Mr. Winchester has played an important part in activity centering around transportation and maintenance, highways, fuel-research, and in addition, has served on the Publications Committee. As a Council member his term extends through 1935.

Mr. Winchester was one of the first transportation and maintenance men in the country to recognize the benefits to be derived by personnel in the field through association with the S.A.E., and has been very active in advancing some of the ideas which led to standards for motor-vehicle maintenance work.

C. L. Cummins

Vice-Presidents : 1935

CHARLES HUGH CHATFIELD, after a year of graduate work at the Massachusetts Institute of Technology, entered aviation during the War years with the U. S. Naval Reserve Force at M.I.T. His government connections continued until 1921 when he joined the Wright Aeronautical Corp. at Paterson, N. J., becoming their chief airplane engineer in 1925. In 1926, Mr. Chatfield returned to M.I.T. as associate professor of aeronautics. He returned to the commercial side of the industry as aeronautical engineer for Pratt & Whitney Aircraft in 1929. At present he is chairman of the Technical Advisory Committee of the United Aircraft Corp., at East Hartford, Conn.

He joined the Society in 1924 and was named to the Aircraft Activity Committee in 1931. In 1933 he became a member of the Wright Brothers Medal Board of Award and in 1934 vice-chairman of the Aircraft Activity Committee. In 1935 he will serve the Society as vice-president representing the Aircraft-Engineering Activity.

Charles H. Chatfield

PHILIP B. TAYLOR, chief engineer, Wright Aeronautical Corp., has been elected vice-president of the Society, representing the Aircraft-Engine Engineering Activity. He joined the Society in 1926 and has been a member of the Aircraft Engine Activity Committee since 1930 serving as its vice-chairman in 1934. He is a member of the Institute of Aeronautical Science.

Graduating from the Sheffield Scientific School of Yale University, in 1920 Mr. Taylor engaged in shop work with several companies for a period of two years. After this varied apprenticeship he joined the Wright Aeronautical Corp. as test engineer in 1922, progressing regularly to his present position in the corporation which he has held since 1929.

Philip B. Taylor

CLESSIE LYLE CUMMINS, who takes office as vice-president representing the Diesel Engine Engineering Activity, is president, Cummins Engine Co., Columbus, Ind., a position he has held since 1913. His name is so closely connected with the development of Diesel engines that it seems like ancient history to recall that he was once associated with the Light Inspection Car Co., and the old Nordyke Marmon Co.

Since 1928 Mr. Cummins has been a member of nearly every important committee having a bearing on Diesel engines. Some of the committees on which he has served include the Engine Division of the Standards Committee, the Diesel Engine Division of the Standards Committee, the Fuels Subcommittee (cooperating with the N.A.C.C., the A.P.I. and the A.S.T.M.), the Diesel Engine Activity Committee, and the joint S.A.E.-A.S.M.E. Diesel Fuel Research Committee.

D. P. BARNARD takes office as vice-president representing the Fuels and Lubricants Engineering Activity. He is assistant director of research, Standard Oil Co. (Ind.) and a member of the American Chemical Society, the American Petroleum Institute and the Institute of Aeronautical Sciences. He has been secretary, vice-chairman and chairman of the Chicago Section and for several years has been a member of the Fuels Subcommittee (cooperating with the N.A.C.C., the A.P.I. and the A.S.T.M.).

He began his research career in 1920 with the Massachusetts Institute of Technology and joined the Standard Oil Co. (Ind.) in 1925 as assistant director of research. He has been a member of the S.A.E. Research Committee for several years and in 1934 served as vice-chairman of the Fuels and Lubricants Activity Committee.

D. P. Barnard

LEWIS P. KALB, chief engineer of the Continental Motors Corp., becomes vice-president, representing the Passenger-Car Engineering Activity. During most of his professional career, Mr. Kalb has been associated with the engineering of automotive engines. The Pierce-Arrow Motor Car Co., the Kelly-Springfield Motor Truck Co., and the Quartermaster Corps, National Army, in which he ranks as major, have all had a place in his working life. In 1921 he joined the Continental Motors Corp. as engineer, becoming assistant chief engineer in 1925 and chief engineer in 1930.

Mr. Kalb has served as chairman of the Truck Division of the Standards Committee, vice-chairman of the Engine Division of the Standards Committee, vice-chairman of the

Lewis P. Kalb

C. O. Richards

V. P. Rumely

Motorcoach and Motor-Truck Activity Committee and has been a member of the Passenger-Car Activity Committee since 1928.

C. O. RICHARDS, chief body engineer, Cadillac Motor Car Co., takes office as vice-president, representing the Passenger-Car-Body Engineering Activity. Mr. Richards entered the automotive industry in 1909 with the Cadillac Motor Car Co., where he gained practical experience in foundry work, pattern making, tool making and tool engineering. He left Cadillac Motor in 1921 to join Mr. Collins in the Collins Motor Car Co., as tool engineer, later serving as factory superintendent when this company joined with the Peerless Motor Car Co. in Cleveland. After serving Peerless three years, he rejoined the Cadillac Motor Car Co. as assistant body engineer in 1924. His position as chief body engineer of the Cadillac Motor Car Co. dates from 1930 at which time he was named to the Passenger-Car-Body Activity Committee of the Society. Mr. Richards has served on the latter committee until the present, and in 1934 became vice-chairman of the Detroit Section, representing the Body Activity.

V. P. RUMELY becomes the vice-president representing the Production Engineering Activity. Since 1915 when he joined the Hudson Motor Car Co. as gear foreman he has held the following positions: Supervisor of method and time study, assistant superintendent, superintendent of car assembly and trimming, general stores manager and factory manager. His present connection is with the same company.

Drawn by Gene Guernsey

Charles O. Guernsey

Previous to working with Hudson he was experimental engineer with the Advance-Rumely Co., La Porte, Ind., and efficiency engineer with the Buick Motor Co., Flint, Mich.

Mr. Rumely joined the Society in 1923 and in 1926 was named a member of the Meetings Committee besides serving as secretary of the Detroit Section. During his connection with the Society he has been a member of the Research Committee, the Special Production Advisory Committee, the Production Activity Committee and vice-chairman of the Detroit Section representing the Production Activity. In 1934 he was a member of the House Committee of the Society.

CHARLES O. GUERNSEY, chief engineer, J. G. Brill Co., Philadelphia, becomes vice-president, representing the Truck, Bus and Railcar Engineering Activity. In 1926 he served the Society as second vice-president representing Stationary Internal Combustion Engineering and has been secretary and chairman of the Pennsylvania Section. His committee work has included service on the Truck Division of the Standards Committee, the Transmission Division of the Standards Committee, the Diesel Engine Activity Committee and the Truck, Bus and Railcar Activity Committee.

Mr. Guernsey has been with the J. G. Brill Co. since 1923, when he joined them as chief engineer, automotive car division. His previous connections were with the Cole Motor Car Co., and the Service Motor Truck Co. He served during the war as captain and chief draftsman in the engineering section, motors division, Quartermaster Corps, U. S. Army.

Council Resolution Concerning the T. & M. Election

AT a meeting of the S.A.E. Council, held at the Engineers Club, New York, Monday, Jan. 7, 1935: Upon motion, duly seconded, the Council voted to adopt the following resolution covering procedure in the matter of electing a vice-president of the Society to represent the Transportation and Maintenance Engineering Activity for the year 1935.

Whereas, the Transportation and Maintenance Engineering Nominating Committee nominated Mr. T. C. Smith for the office of Vice-President representing Transportation and Maintenance Engineering for the year 1935; and

Whereas, the Special Transportation and Maintenance Engineering Nominating Committee nominated Mr. F. C. Patton for the office of Vice-President representing Transportation and Maintenance Engineering for the year 1935; and

Whereas, after the balloting commenced, but before the election closed, Mr. F. C. Patton withdrew his candidacy; and

Whereas, notwithstanding the withdrawal by Mr. F. C. Patton of his candidacy, a majority of the votes cast for the office of Vice-President representing Transportation and Maintenance Engineering were received by Mr. F. C. Patton; and

Whereas, the counsel for the Society has advised the Society in a written opinion dated December 24th, 1934, and presented to this meeting, that the result of the withdrawal by Mr. F. C. Patton of his candidacy, under the circumstances, is that the election failed with respect to the office of Vice-

President representing Transportation and Maintenance Engineering; that there is a vacancy in the office of Vice-President representing Transportation and Maintenance Engineering; and that this vacancy can be filled only by a special election to be held for that purpose.

Now, therefore, be it

Resolved, that a special election be held to fill the vacancy in the office of Vice-President representing Transportation and Maintenance Engineering, such election to be conducted in the following manner:

(1) The Transportation and Maintenance Engineering Nominating Committee, consisting of F. C. Horner, Chairman, R. T. Hendrickson, B. J. Lemon, and A. R. Platt, shall send to the secretary of the Society on or before January 21, 1935, the name of one consenting nominee for the Vice-Presidency representing Transportation and Maintenance Engineering; and the secretary of the Society is hereby instructed to promptly transmit to Mr. F. C. Horner, Chairman of said Nominating Committee, a copy of this resolution and the preambles thereto;

(2) The secretary of the Society shall cause a copy of this resolution and the preambles thereto to be published in the February issue of the Journal of the Society, and in connection therewith there shall also be published the name of the consenting nominee for the Vice-Presidency representing said activity sent to the secretary of the Society by the said Nominating Committee;

(3) Twenty or more members of the Society entitled to vote may organize a special nominating committee, as prescribed by the Constitution and By-Laws of the Society, and, if organized, shall on or before February 21, 1935, send to the secretary of the Society the name of the candidate nominated by it for the office of Vice-President representing Transportation and Maintenance Engineering for the year 1935, together with a written consent of the candidate;

(4) The secretary of the Society shall cause to be published in the March issue of the Journal of the Society a notice setting forth the names of nominees selected by all nominating committees;

(5) The secretary shall mail on or before March 4, to each member of the Society entitled to vote, a ballot containing the names of the candidates for the office of Vice-President representing Transportation and Maintenance Engineering, with appropriate instructions for voting, the election to be conducted in the same manner as is prescribed by the Constitution and By-Laws of the Society with respect to the annual election of officers.

The time of closure of voting is hereby fixed as April 15, 1935, and the Tellers shall not receive any ballot after the stated time fixed for the closure of voting. Within seven days thereafter, the Tellers of election heretofore appointed to serve for the annual election of officers for 1935 shall canvass the ballots in the manner prescribed with respect to the annual election and forthwith inform the Council and the candidiates of the result. The candidate elected shall forthwith assume the office to which he has been elected, and the Secretary of the Society shall publish in the next succeeding issue of the Journal of the Society an announcement of the result of this special election.

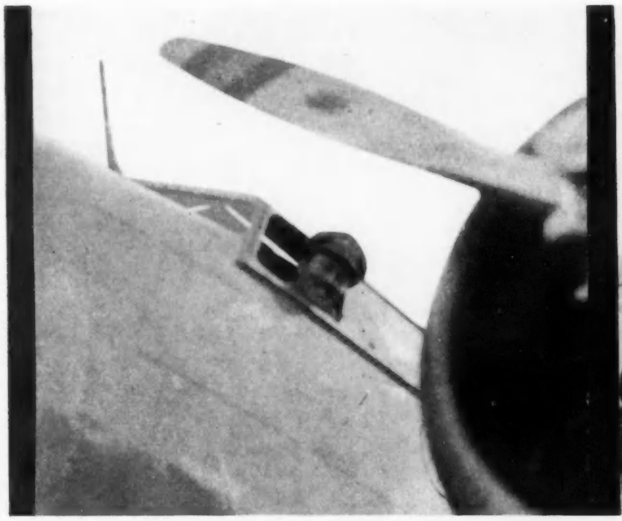
Nomination for Vice-President

FOLLOWING is the nomination for vice-president of the S.A.E. representing the Transportation and Maintenance Engineering Activity for 1935:

T. C. Smith

Engineer, Motor Vehicles and Construction Apparatus, American Telephone & Telegraph Co.

The above nomination was filed for the 1934 Transportation and Maintenance Activity Nominating Committee by F. C. Horner, chairman; B. J. Lemon; A. R. Platt; Henry Dakin, alternate; and Pierre Schon, alternate.



Col. Roscoe Turner flew his famous England-to-Australia Boeing plane east from California, especially to be present at the Thirtieth Anniversary Dinner of the S.A.E., held in New York, Jan. 7. The picture at the left shows the reception committee's first glimpse of Coloner Turner, after he landed at an airport near New York. The picture at the right shows Colonel Turner (in uniform) with part of the reception committee which turned out to greet him

Packed Sessions Hear Debates at Record Annual Meeting

(*Continued from page 22*)

tion. A controlling influence, he said, is the dictation of scheduled times for air mail by the government, which reduces operating effectiveness for airline operators. The length of time per day that a plane is in service, he said, is not necessarily indicative of the quality of the management in this respect.

Mr. Littlewood, discussing Mr. Kindelberger's half of the Kindelberger-Atwood paper, disagreed as to dangers involved in the use of exhaust type cabin heaters. He said these should be easily serviceable, however, and should preferably be made from unwelded seamless stainless steel tubing.

Fuels and Lubricants Sessions

Thursday morning's session was scheduled as a conference on oiliness of crankcase oils and lubrication of copper-lead bearings, but included other related items. The two preliminary reports presented were not made available for distribution or publication and were read only in abstract, primarily because the data collected to date are fragmentary and are far from being conclusive.

Some of the points brought out by Dr. G. M. Maverick, the first speaker, include the following taken from a summary of replies to a questionnaire by fourteen firms in the automotive, petroleum, aviation and lubricant supply fields:

Three automotive concerns reported no advantages realized so far by use of addition products (compounded oils), but have open minds and await conclusive data. Oil company engineers are divided, most of them feeling that improved oiliness with compounded oils is reflected in improved engine lubrication; others expressed doubt. The one aviation company replying reported very favorably on compounded oils. No corrosion of bearings was observed and greatly increased bearing life resulted when operation was under extreme test conditions. Lubricant specialty manufacturers considered that they had evidence of improvement in service but did not present data obtained under controlled conditions. Few data in connection with the use of the newer bearing materials were presented by this group. Opinion on effects on engines, aside from bearing effects, is rather evenly divided, but there is agreement regarding the need for compounded oils during running-in periods on new engines. Some evidence indicates decreased wear and longer bearing life, assuming that corrosion effects do not enter.

H. C. Mougey's remarks supplemented what he reported on copper-lead bearings at the 1934 Summer Meeting of the Society and embraced remarks concerning several slides which were shown. Some of these remarks were the result of a questionnaire prepared on behalf of S.A.E. committees. The remarks indicated that compounded oils are now being sold in commercial quantities. Some such oils and addition agents are believed to have no harmful effect on copper-lead and other newer types of bearings. Others have a detrimental and destructible corrosive effect on certain alloys. Though some compounded oils reduce bearing friction in bearing-test machines, no data have been presented to show this reduced friction in engines. Data are too meager to permit definite conclusions as to either friction or durability of engine parts. Commercial bearing alloys in current production engines operate satisfactorily with straight mineral oils and do not at present require the use of compounded oils or addition agents. The only conclusive test that will determine the effect of a particular combination of lubricant and bearing alloy is a specific engine test under service conditions. A change in engines or in conditions of operation or in the combination of lubricant and alloys involved may produce different results. Some combinations of bearing alloys with mineral oils, compounded oils or mineral oils plus addition agents are satisfactory and others are not. If compounded oils are used, the non-injurious ones should be selected.

In view of the lack of specific data which the speakers mentioned and the conflicting opinions held by those they questioned, it was not surprising that discussers took differing points of view. Those who took part in the discussion included G. C. Brown, A. W. Burwell, W. H. Graves, E. A. Sperry, B. E. Sibley, F. C. Burk, 2nd, Neil MacCoull, C. M. Larson, R. R. Teetor and A. L. Beall. The last named acted as chairman of the meeting. Lack of space prevents doing full justice to the discussion, but some of the points brought out follow:

Some compounded oils are very sensitive to temperature. A difference of ten deg. fahr. above a certain critical temperature may result in their becoming highly corrosive whereas below this temperature they may prove satisfactory. Reduced temperature sometimes results in reduced corrosion and rapid oil circulation may aid by helping to avoid high temperatures. Oiliness, increased by compounding, may reduce internal friction in film and hence reduce heating. Viscosity is less important when oiliness is present. Formic and acetic acids, if formed, are corrosive but other acids may not result in difficulties under some conditions. In certain instances alloys are not affected, whereas mechanical mixtures, such as those in copper-lead bearings, may be badly affected or even disintegrated. Under certain wide-open testing of engines, bearings have run 25,000 miles without serious wear with mineral oils but have shown serious wear after 3700 miles with certain compounded fatty oils. Wear of cylinders is less with certain compounded oils in tests with steady high temperature, but frequent starting and stopping with accompanying temperature changes tend to increase wear.

A. Ludlow Clayden was chairman at the Fuels and Lubricants Session Friday afternoon. A report of the Cooperative Fuel Research Committee on the 1934 Detonation Road Tests, prepared by C. B. Veal, Secretary of the Committee, was presented by Prof. H. W. Best.

Dr. C. H. Schlesman of Socony-Vacuum, presented the first paper entitled "The Lubrication Requirements of Automotive Worm Gearing" and was highly complimented upon the thorough-going and comprehensive research which the paper represents, as well as upon the paper itself. The paper "explains some of the lubrication requirements of worm gears and pointed out the influence of various types of lubricant upon performance." One of the conclusions drawn is that "although certain specialized lubricants may prevent tooth destruction in the case of extreme overloads, in ordinary practice all really good lubricants will hold the rate of pitting to the minimum practicable." The paper gave a specially compounded oil a weighted rating of 68, a mineral oil a rating of 67 and a vegetable oil a rating of 62, others having lower rating, as applied to average fleet operations.

In the discussion G. L. Neely indicated that extreme-pressure lubricants, even though designed for lubrication of hypoid or other steel-on-steel gears are finding use in worm gears on the Pacific Coast and are not considered separately. Dr. H. C. Dickinson said he was glad to see the paper bring out three characteristics, namely, the tendency to seize or pit, the rate of wear and the stability of the lubricant, none of which are related. He cautioned against drawing conclusions from any one alone. Another discusser remarked on heat effects and the higher temperatures attained by certain of the lubricants tested. The latter he indicated are apt to lead to wrong conclusions or to unfair comparisons from a certain point of view, especially as oxidation of the oil occurs more rapidly as the temperature is increased. He mentioned that worm bearings are pre-loaded and that wheel bearings do go out of line. He also said that tests at various temperatures using the same lubricants had been run so as to take account of temperature effects.

The report on detonation fuel tests laid more stress on engine than on fuel factors, as the latter had been treated in a report before a recent A.P.I. meeting. As the report covers many thousands of words besides tables and charts, space precludes any satisfactory summary in a limited space here.

Those taking part in the discussion included D. B. Brooks, W. H. Hubner, L. B. Kimball and G. L. Neely.

Passenger-Car Brakes Argued

"Hydraulic Brake Actuation" was the title of the first paper, presented by Burns Dick, at the Passenger-car Brake Session. G. L. McCain presided. Mr. Dick gave a clear-cut statement of the advantages of hydraulic brakes and certain data on their performance. "For the average passenger car," he said, "it is now generally recognized that it is desirable to proportion the braking effect in such a manner that more than half is applied to the front wheels. . . . This corresponds with more favorable cooling conditions encountered on the front wheels, and results in greater uniformity in operation, since excess heat dissipation can be better accommodated on the front wheels than on the rear wheels."

Discussion was combined with the second paper of the session, on brake drum and lining development, which was presented by the two authors, Chris Bockius and J. Harold Hunt. "The purpose of the paper", said the authors, "is to delineate some of the equipment required for brake tests, together with the methods employed to interpret the results of the data obtained. . . . With the streamlining of bodies, the entire brake assembly is being housed to such an extent that heat is becoming a very serious problem. . . ." These and other factors "combine to make the retarding of a motor vehicle one of the major engineering problems of today".

Joseph A. Anglada opened the discussion by citing one failure of hydraulic brakes which he attributed to overheated fluid in the brake tubing connections. He also asked what constitutes an ideal brake lining. Mr. Horine asked why, if hydraulic brakes require no adjustment, sixteen points where adjustment can be made are provided? Mr. Dick replied that eight of these are for original adjustment by the manufacturer.

There was considerable difference of opinion about the degree of self-energizing desirable, two speakers indicating respectively that it should not exceed 30 per cent or 50 per cent. R. E. Berg drew a rough curve showing the relation between energy absorbed and temperature attained by linings. Above 350 deg. fahr. the energy rises rapidly but the rate of wear resulting becomes excessive, hence, he indicated, much longer life is realized if the temperature is kept below 350 deg. fahr. Mr. Berg said that an excellent measure of brake effectiveness can be obtained by dividing the rate of deceleration possible by the pedal pressure which is exerted to obtain this deceleration. Mr. Bockius stated that an ideal brake lining is one which does not show differences in performance over a wide range of operating conditions, but added that a film of foreign matter sometimes builds up on a lining surface which interferes with satisfactory operation.

There was considerable discussion as to the relative severity of brake service on airplanes, cars and trucks.

Flame Movements at Engine Session

Friday morning's passenger-car engine session, with F. F. Kishline, assistant chief engineer, Graham Paige Motors Corp., in the chair proved no exception to the rule that the topic of combustion chambers always causes sharp debate at S.A.E. meetings. Reminiscent of the first of the series—the famous Taub-Watmough-Janeway three-cornered controversy —was the discussion following the presentation of a paper by C. C. Minter, consulting chemist, entitled "Flame Movement and Pressure-Development in Gasoline Engines".

The other paper of the session, "Engine Flame Temperatures Vary with Knock and with Position in the Combustion Chamber", by G. M. Rassweiler and Lloyd Withrow, General Motors Research Laboratories (presented by Mr. Rassweiler), also came in for its share of the discussion, particularly in reference to the findings expressed on causes of radiation, and on "afterburning".

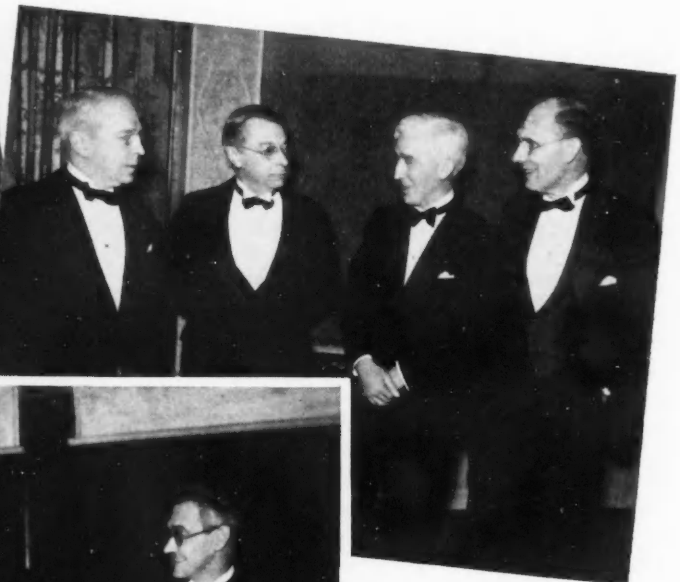
It was Dr. Minter's paper, however, which provoked the most heated argument. Again the debate was largely three cornered, with Alex Taub, Chevrolet Motor Co., and R. N. Janeway, Chrysler Corp., taking a leading part. This year, however, found Messrs. Taub and Janeway on somewhat opposite sides of the fence.

Paul G. Hoffman, director, Automobile Manufacturers Association; Harvey Firestone, pioneer in the rubber-tire industry, and Charles Duryea, who built one of the first successful gasoline-propelled automobiles in the United States, were guests at the speakers' table.

PIONEERS ATTEND 30TH ANNIVERSARY DINNER

D. G. Roos, retiring president of the Society, presided at the Thirtieth Anniversary Dinner in New York, Jan. 7. At Mr. Roos's right in the picture above is Col. Roscoe Turner, guest of honor, and William B. Stout, president of the Society for 1935, who also spoke at the dinner.

See page 32 for story of dinner



John N. Willys, chairman of the board, Willys-Overland, Howard Marmon, an early president of the Society; Gar Wood, trail-blazer with speedboats; and Charles F. Kettering, whose name is synonymous with the beginnings of automotive research, were bright stars in the galaxy at the speakers' table.

Dr. Minter in discussing combustion roughness laid considerable stress on the design of a chamber which would maintain maximum rate of pressure rise at the minimum, differing from Mr. Janeway's previously expressed views on the relatively greater importance of acceleration in the rate of pressure rise.

In one respect Mr. Janeway and Dr. Minter agreed—the determination of combustion chamber shape, etc., by mathematical analysis and computation based on predetermined desirable characteristics.

Here Mr. Taub differed with both Mr. Janeway and Dr. Minter, and in his discussion gave a brief resume of the method adopted by his organization in designing combustion chambers. This consists quite largely of empirical comparisons of different heads in actual use, followed by analysis of these heads to determine what relationship of volume to flame travel produces rough or smooth heads.

In his discussion Mr. Taub stated that a combustion chamber can be divided into three parts by volume, the first of which controls heat-loss, the second or middle part roughness, and the third part detonation.

From this standpoint, Mr. Taub stated, considerable gains in fuel economy and decreased radiator capacity can be secured by actually providing a heat-input to the first part of the gas to burn, thereby reducing the heat loss to the cylinder head walls, etc. He showed slides of several cylinder head curves of volume vs. flame travel, illustrating virtually equal smoothness for two combustion chambers of totally different designs, and large differences in smoothness for two quite similar heads.

Everybody, however, seemed to agree that the question of volume distribution in a combustion chamber is vitally important—the difference of opinion being as to how that volume distribution should be determined.

Mr. Taub's method of studying chambers is by making plaster casts and cutting these into sections with a special tool making spherical cuts with the spark plug as the center, and then measuring the volume of remaining portions to determine what volume has already been burned.

Dr. Minter and Mr. Taub agreed that changes in compression ratio and b.m.e.p. have a vital effect on combustion chamber design, and that when changes in these factors are made findings on one chamber would not be applicable necessarily to the second head.

Mr. Taub also showed results of studies which support general assumptions made by most designers that, when computing volumes burned, etc., at different stages of flame travel, for all practical purposes the piston can be assumed to be standing still.

Mr. Janeway reiterated that "the industry is having a hard time trying to unsell itself on the importance of turbulence in combustion chamber design" as originally propounded by Ricardo. The assumptions of Dr. Minter on velocity of flame propagation are erroneous, because his curves showing zero velocity at beginning and end of burn, according to Mr. Janeway, whereas, Mr. Janeway contends, these values were of finite values and quite high; and that velocity of flame travel is a function of some power. Mr. Janeway said that one of Dr. Minter's illustrations itself showed relatively equal maximum rate of pressure rise for a smooth and a rough chamber

while the rough chamber had a much higher maximum acceleration rate.

A point brought out in Messrs. Rassweiler's and Withrow's paper that exhaust gases are cooler for knocking than for non-knocking combustion and interpreted as indicating higher heat transfer to the walls due to turbulence brought about by the knocking combustion itself, was supported in a written discussion of the paper by Bernard Lewis of the U. S. Bureau of Mines.

Another point brought out in the same paper, dealing with apparent temperature rise of the products of combustion near the spark plug (after-burning), was attributed by Charles F. Marvin, Jr., and Frank R. Caldwell, of the National Bureau of Standards, in a written discussion read by H. K. Cummings of the Bureau, to compression of the burnt gases, as combustion proceeds.

Others who contributed to the discussion included Guenther von Elbe, of Carnegie Institute, and A. E. Hershey and R. F. Paton, University of Illinois, whose written discussion was read by Chairman Kishline.

Production Topics Varied

The closing session of the annual meeting, devoted to manufacturing problems, established a new high record of interest for the S.A.E. Production Activity. The large meeting room was filled to overflowing.

Five papers were presented. W. H. McCoy, General Motors Corp., was chairman. The general topic was "Recent Outstanding Developments in Production Machinery and Methods." Discussion was chiefly in the nature of questions for further information.

Answers to questions on the first paper "Single Point Boring of Cylinders and Diamond Turning of Pistons", by W. F. Wise, Ex-Cell-O Aircraft & Tool Corp., were handled by Ira Snader of the same company, who explained that the reason for the use of diamonds for the turning of pistons in the example discussed in the paper was that the piston was relatively frail and other cutting tools—by requiring higher pressures—would have distorted the piston while turning. Mr. Snader added that he has found diamonds better than cemented tungsten carbide for piston turning.

Single point boring of cylinders to a semi-finished condition was another point in Mr. Wise's paper, which caused some question. He brought out that tool marks left after this operation had a depth of approximately 0.00015 in. so that a 0.0003 to 0.0006 in. honing operation was all that was necessary for final finishing.

The paper also precipitated another discussion on the relative advantages of smooth vs. slightly rough cylinder bores in relation to oil consumption during the break-in period, involved in the question of relation of "roughness" to "wear". This part of the discussion, however, came after discussion of the paper by E. J. Abbott, Research Physicist, University of Michigan, on "What is Surface Finish and How Can It be Beasured and Specified"? Thus both Dr. Abbott and Mr. Snader were involved.

O. E. Kurt, U. S. Rubber Products, Inc., asked the question which precipitated the argument: "What is the relation of roughness to wear?" To this Dr. Abbott replied that no one has been able to find out previously because that was no adequate means available of actually measuring "roughness". Dr. Abbott's paper had dealt largely with developments of roughness measurements by the profilograph method, involving the use of a specially developed instrument.

In answer to a question by J. Geschelin, *Automotive Industries*, Dr. Abbott said that only one profilograph so far had been built—at a cost of roughly $10,000 for development, and that the cost would be too high for general use in the industry. He recommended that special purpose machines of simpler character be developed for commercial application. Dr. Abbott also contended that if production samples were checked by the profilograph, visual comparison with the standards established would provide a pretty fair guide in actual production.

In a prepared discussion presented at the session K. L. Herrmann, Bantam Ball Bearing Co., recommended use of microscopic inspection for roughness determinations. Dr. Abbott replied that microscopic checks were advantageous for comparative work but provided no "numbers" for standardization work.

Some discussions also resulted regarding possibilities of setting "standards" for surface finishes. It seemed to be the consensus of opinion that no general standards could be set, but that different parts would have to be classified to establish finish standards.

Howard W. Dunbar, Norton Co., who presented a paper entitled, "1934 Developments in Cam Grinding and Cylindrical Grinding", added to the discussion mentioned above that a "mirror" finish is not necessarily a smooth finish, and that a lot depends on the preparation of the material under the surface.

Interesting information on grinding was given by Mr. Dunbar in the discussion during which he showed slides and explained the functioning of a new grinding method under development by the Norton Co. Called "conjugate principle of grinding", the process is adapted to the finishing of non-cylindrical surfaces on fixed centers. Thus, with this machine, all the cams of a camshaft can be ground simultaneously, with all grinding wheels on one spindle and the camshaft on fixed centers. This is achieved by use of eccentrically shaped grinding wheels, the eccentricity or shape being determined by the shape of the cam.

So far this item of equipment is still listed as experimental and is not released for production by the Norton Company.

The paper "Surface Integrity and Dynamic Strength", by A. V. DeForest, associate professor of mechanical engineering, Massachusetts Institute of Technology, dealt largely with fatigue testing and necessity for surface inspection of parts subject to high stress reversals in operation. Part of the paper dealt with experiments conducted in cooperation with the Surface Transportation Corp., of New York. In discussion, William J. Cumming, of the latter organization, said that 75 per cent of their fatigue failures in service had been directly traced to surface imperfections. He added that they had even found parts with surface cracks resulting from heat-treatment—parts supposedly of highest quality.

The fifth paper on the program, entitled "Modern Resistance Welding in the Automobile Industry", by P. W. Fassler, of P. W. Fassler and Co., welding consultants, was a profusely illustrated lecture on welding practices, chances of trouble with welding equipment, etc. Of particular interest to the audience apparently were references to the low power factors of present welding equipment and the possibility of reducing sizes and costs of welding machinery by improving the power factor.

30th-Anniversary Dinner Draws 800

Past-Presidents Get Life-Membership Honor

In opening the Thirtieth Anniversary Dinner President Roos congratulated the Society on attaining its thirtieth birthday.

"It has become one of the most important technical bodies in the world," he said, "and its mouthpiece, the JOURNAL, is found on every automotive engineer's desk, irrespective of country."

Then turning to the past-presidents seated at the speakers' table he reminded the audience that not a little of the achievement of the Society could be traced to the activity and loyalty of its officers during the formative days. To the past-presidents he said "Cars and trucks and airplanes will change—but the ideals and high ethical standard you have woven into this Society will remain unchanged while it endures."

He then read a Council resolution, passed at the Dec. 18 meeting in Detroit, conferring Life Membership in the Society to Past-Presidents who have completed their Council term. The resolution reads:

Presidents of the Society, at the expiration of their three-year term on the Council, as President and Past-President, automatically become Life Members of the Society. Further that this action applies to all living Past-Presidents, effective as of Jan. 1, 1935.

All the Past-Presidents named below were made life members.

PAST-PRESIDENTS

	Served
T. J. Fay	1908
Howard E. Coffin	1910
H. W. Alden	1912 & 1923
Howard Marmon	1913
George W. Dunham	1917
C. F. Kettering	1918
J. G. Vincent	1920
David Beecroft	1921
B. B. Bachman	1922
H. M. Crane	1924
H. L. Horning	1925
T. J. Lítle, Jr.	1926
J. H. Hunt	1927
W. G. Wall	1928
W. R. Strickland	1929
E. P. Warner	1930
Vincent Bendix	1931
A. J. Scaife	1932

IN two or three years from now, all the utilities of our everyday life will be obsolete, declared William B. Stout, president-elect of the Society, who was the lead-off speaker at the Thirtieth Anniversary Dinner, held in New York Jan. 7. Mr. Stout was emphatic in declaring that the economic obsolescence which is attacking the world's goods offered an unparalleled opportunity for the automotive engineer.

Besides introducing Mr. Stout, and Col. Roscoe Turner, the second speaker of the evening, President D. G. Roos was charged with the pleasant duty of presenting life membership in the Society to all its living past-presidents who have completed their *ex-officio* term with the Council.

He also presided at a short business meeting during which F. C. Mock, vice-president, Bendix Products Corp., presented the report of the tellers on the election of the Society's officers for 1935.

The Grand Ballroom of the Hotel Commodore was filled nearly to capacity for the Thirtieth Anniversary Dinner. At the speakers' table were nearly all the living past-presidents of the Society and an unusually representative gathering of executives.

Turner Thrills Audience

From the first rap of President Roos's gavel to the last flicker of the pictures shown by Colonel Turner, the dinner was applauded to success by the 800 or so persons who attended.

Colonel Turner figuratively turned the audience upside down with his casually told tale of a gallant flight across the under side of the world in the London-Melbourne air race. One gathered from his recital that not least among the difficulties of an international air race was the business of getting a plane with crew and equipment on the ground for the start.

The audience was thrilled and amused by turns, and if they were not completely his at the end of the recital, they were when President Roos announced that he had in his pocket Colonel Turner's application to join the Society which had "received him so well."

The dinner began almost exactly to the scheduled minute. No little credit for this must be given to the efficient reception committee provided by the Metropolitan Section, headed by Sid G. Harris, its chairman.

Speakers' Table Has Brilliant Convocation

The Thirtieth Anniversary Dinner of the Society was virtually the only formal gathering held during Automobile Show Week in New York. Because of the fact that the Automobile Manufacturers Association and the Rubber Manufacturers Association did not hold their usual events, members of these and other automotive organizations were invited to be guests of the S.A.E. The friendly response to these invitations was gratifying to the officers of the Society, and resulted in an unusually brilliant convocation at the speakers' table for the Thirtieth Anniversary Dinner.

Besides the past-presidents eligible for the award of Life Membership in the Society, those present at the speakers' table were:

SPEAKERS' TABLE

S. G. HARRIS, Chairman, Metropolitan Section
E. T. SATCHELL, President, Motor & Equipment Wholesalers Association
HANS OSTERMAN, President, A/B Hans Osterman, Stockholm, Sweden
J. C. HUNSAKER, Federal Aviation Commission
R. E. FLANDERS, President, American Society of Mechanical Engineers
PYKE JOHNSON, Vice-President, Automobile Manufacturers Association
THOMAS H. MACDONALD, Director, Bureau of Public Roads
GARFIELD A. WOOD, Pioneer in Automotive fields, particularly the Marine Field
BYRON C. FOY, Director and Secretary, Automobile Manufacturers Association
JOHN N. WILLYS, Chairman of Board, Willys-Overland Co.
R. E. OLDS, Pioneer and Chairman of the Board, Reo Motor Car Co.
CHARLES E. DURYEA, Pioneer
HARVEY S. FIRESTONE, Pioneer
PAUL G. HOFFMAN, Director, Automobile Manufacturers Association
EUGENE L. VIDAL, Director of Air Commerce
F. J. HAYNES, Treasurer, Automobile Manufacturers Association
ALFRED REEVES, Vice-President and General Manager, Automobile Manufacturers Association
WILLIAM L. COLT, Chairman Show Committee, Automobile Merchants Association
CLIFF BISHOP, Chairman Show Committee, Automobile Merchants Association of Brooklyn
T. D. PRATT, President and General Manager, New York Motor Truck Association
C. B. WHITTELSEY, one of our pioneers—for 12 years treasurer of the Society
F. H. RUSSELL, President, Manufacturers Aircraft Association, Inc.
H. C. DICKINSON, Past President, S.A.E., 1933
D. G. ROOS, President, S.A.E.
COL. ROSCOE TURNER

1935 Annual Meeting Papers in Digest

HERE are digests of all the papers presented at the 1935 Annual Meeting. Next month will appear, in similar ready-reference form, digests of the discussion which took place following presentation of each of these papers.

* * * *

Some of these papers and discussions later will be printed in full in the S. A. E. JOURNAL.

Mimeographed copies of *all of them* will be available until current supplies are exhausted, at a cost of 25c per copy to members; and at 50c per copy to non-members. Orders for mimeographed copies must be accompanied by remittance and should be addressed to Sessions Secretary, Society of Automotive Engineers, 29 West 39th St., New York.

Transportation and Maintenance Session

Monday, January 14

How To Finish A Truck—*P. R. Croll, Pittsburgh Plate Glass Co., and L. E. DuBey, Ditzler Color Co.*

THE paper states that no one simple answer will ever finally dispose of this question. Honest differences of opinion encourage new developments of better materials and methods. Patience does not lead directly to progress nor does chaos always follow change. A useful discussion of finishing trucks—including buses, delivery wagons and similar vehicles—must consider both technical and commercial details of the problem. Body Builders, Fleet Owners and Operators, and Finishing Shops, have much in common.

Whether specified by a fleet owner, recommended by the finishing shop, or adopted by the original body-builder, the selection of a finishing system will usually be a compromise. The important factors in most cases, in selecting a truck-finishing system, are deciding; they are: Reputation for durability in service, initial beauty or appearance (smooth, glossy, deep finish), color harmony, suitability as to design and surfaces to be coated, convenience of the system (utilization of available equipment), ease of using materials, and material and labor costs.

The subjects discussed include the available classes of finishing materials, nitrocellulose lacquers, synthetic resins, and the requirements of a properly equipped finishing shop. A typical finishing specification is stated, and a suggestion is made for a permanent Board or Committee on "finishing."

How to Buy a Truck—*T. L. Preble, Tide Water Oil Co.*

THE author makes the point that the purchase of a truck should be preceded by a careful analysis, by means of which the most efficient use of present equipment may be insured. The specific elements of such analysis are enumerated and discussed.

As an additional pre-requisite to purchase, suitable standards, based on job analysis and comparative specifications should be set up. These standards are outlined—as are considerations in connection with the relationship which should exist between buyer and seller.

Emphasis is made of the fact that all of the foregoing procedure is of importance if purchases are to be made intelligently, and that the necessity therefore exists for the granting to the automotive personnel of the buyer adequate authority covering not only maintenance, but retirement, allocation, and selection as well.

Transportation and Maintenance Luncheon

Monday, January 14

Motor Vehicle Design from the Operation and Maintenance Standpoint—Part II—*Fred L. Faulkner, Armour & Co.* (Part I was presented at the 1934 Summer Meeting and published in the JOURNAL, September, 1934.)

THE sub-committee on motor vehicle design from the operation and maintenance standpoint of the transportation and maintenance committee of the Society of Automotive Engineers was instructed to continue its studies and prepare a short summary for the 1935 Annual Meeting.

In discussing the possible subject matter with the committee there were so many phases of this subject that were questioned that it was impossible in a short space of time to give them full consideration in time for this presentation. I have therefore limited the report to cover mainly the electrical group and the highly controversial subject of motor-truck ratings.

The largest number of complaints and the most severe criticisms on the electrical group come from fleet operators in the so-called low temperature area. Winter starting difficulties are prevalent, not only on account of inadequate storage batteries and starting motors but inefficient generators as well. Likewise this problem is all tied in with the much discussed problem of winter grades of crankcase lubricating oil.

I have not attempted to define where the starter battery difficulty stops and the lubrication problem begins. However, I am of the opinion that if engine design were improved to the point where 20-W oils could be used eeconomically in all makes of motor vehicles our winter starting difficulties would be minimized.

I have set up data showing the inconsistency that exists between the generator-battery starter-combination as applied by various manufacturers. It is obvious that the winter starting requirements are not generally known. It is the general feeling among the operators that this subject is of sufficient importance to warrant special treatment on the part of the manufacturers.

Motor truck ratings have been discussed pro and con over a period of years with nothing tangible developed that the operator could use as a guide in the purchase of motor vehicles for a definite transportation job. I have attempted to correlate sufficient data furnished by the manufacturers and using their own advertised ratings to show first the lack of consistency and second lack of standardization.

The method used in developing this practical rating is simply taking the manufacturers' advertised gross vehicle weight with his advertised standard axle ratio, equipping that vehicle with sufficient tire size to comply with the Rubber Association's rating for the particular gross vehicle weight and for the performance factor, and computing the grade ability at 20 m.p.h.

As a check on the strength of the component units in the vehicle—the front axle knuckle diameter at the inside bearing, the rear axle, outside tube diameter full floating type, section modulus of frame, clutch area, effective braking area, and engine displacement, all computed in terms of per thousand pounds gross vehicle weight, maximums, minimums and averages have been set up for all classes of vehicles.

To the operator it is intended as a guide to rate a vehicle for a specific job. To the manufacturer we trust it will be used for the production of a better balanced vehicle.

Truck, Bus and Railcar Session

Monday, January 14

Engineering Uses of Rubber—*Curt Saurer, Firestone Tire & Rubber Co.*

THE rubber tire and later the air containing tube made it possible to ride in the early automobile. Since that time the many changes in the proper manufacture and use of the steel parts have made high speed possible but the proper manufacture and use of rubber has made high speed with comfort possible.

The automobile tire and tube of today are still made of rubber and are much better than those on early models but it would be hard to imagine a modern car with only the tire and tubes made of rubber. Today rubber is not only used to increase the passenger's comfort but also to lessen the strain on part of the machine itself.

It is possible to compound and design the rubber part to fulfill almost any requirement in automobile construction; however, every case and condition is a problem within itself. The rubber engineer can point with pride to the contributions he has made to the modern car and he feels that there is much more that he can do. Data are presented to show that with rubber fabrications it is possible to obtain cushioning properties that are impossible to obtain with steel springs of commercial size. The data also explain the reasons why certain parts are built as they are and also why it will be possible to build still other parts in the future.

Cooperation of the automobile engineers and builders with the rubber engineer will result in many new uses for the very useful and needed products made of rubber.

Student Session

Monday, January 14

Controlling Noise—*H. R. Berlin, assisted by John S. Parkinson, Johns-Manville Corp.*

THIS lecture is almost a complete course in the fundamentals of sound and its practical applications in automotive engineering. A complete exposition of the fundamentals of sound, its physical and psychological aspects, will be presented in laboratory form by means of a sound movie. This will be followed by demonstrations of sound absorption and an exposition of the required instrumentation.

The problem is either the absorption of vibrations before they produce sounds, or the absorption of the sounds after they are produced. The results of research in the automotive field and other fields will be combined to show the effective means which have been employed in the silencing of auditoriums, theaters, offices, and automobile bodies. There is much in common in the problems of different industries.

Aircraft-Engine Session

Tuesday, January 15

Aircraft and Aircraft Engine Performance as Influenced by Engine Oils—*S. D. Heron, Ethyl Gasoline Corp.*

WITH increasing specific and total output of aircraft powerplants oil cooling is an increasingly difficult problem. The weight and drag of the oil coolers necessary with the present maximum "oil in" temperature of 185 deg. (85 deg. cent.) are both decidedly objectionable. It appears possible to increase the "oil in" temperature to about 220 deg. fahr. (104 deg. cent.) with oils which can be produced by the newer refining methods. The use of an "oil in" temperature of 220 deg. fahr. would render possible a material reduction in weight, size and drag of oil coolers in comparison with present practice. Oils suitable for use at 220 deg. fahr. "oil in" temperature would not be likely to cause a material increase of engine starting difficulty, as they would only be used in summer when the shearing resistance of the oil has slight influence on engine starting. The approximate temperature cycle encountered by the oil in its passage through a modern aircraft engine is discussed. The not generally realized importance of oil as a heat transfer agent in the high duty aircraft engine is briefly referred to. The lack of adequate knowledge of oil stability is dealt with. It is stated that only extensive service tests of an unknown oil, will, in the light of present knowledge, determine its stability. It is stated that stability as determined by examination of the used oil and by engine effects are usually similar but not always so, and that the latter is much the most important.

Winter Operation of Aero Engines—*Alan Ferrier, Royal Canadian Air Force.*

THE author describes the conditions of aircraft operation in Canada during the winter and after outlining the laborious technique pursued for several years emphasizes the need for improvement in lubrication and starting technique in order that commercial undertakings may make full use of the short northern day.

The elimination of cold weather lubrication difficulties is based on the proposition that oil temperature is in itself immaterial and that its only real importance is the effect on viscosity which is regarded as a *state* rather than as a *property*. In consequence a variation of oil grade and a premeditated variation of oil operating temperature under adequate control is advanced as the solution and the results of two years practical trial are offered as proof. A brief specification of a desirable oil system is given, together with a forecast of possible developments in the near future to deal with existing lubricants.

Cold oil having been proved to be effective down to temperatures of 25 deg. below zero Fahrenheit, extension to lower temperature ranges again brings to the fore the problem of obtaining the first ignition. The use of booster devices for the ignition in conjunction with special starting fuels is contemplated and briefly discussed. The necessity for engine warming equipment cannot be ignored for some time and desiderata for this are submitted.

Lubrication of valves, and valve gears, requires attention. The lubrication of accessories such as starters is a big problem in itself.

Difficulties in connection with ice in the carburetor are, if anything, rather less severe in Canada than in the warmer but damper regions farther south.

Progress Report of C. F. R. Aviation Gasoline Detonation Subcommittee—*Arthur Nutt, vice-president in charge of engineering, Wright Aeronautical Corp.*

THE objective of this Subcommittee is to develop a standard method for the knock rating of aviation gasolines which will be applicable to all varieties of fuels and to all types of spark-ignition aircraft-engines. The accepted A.S.T.M.-C.F.R. method of rating motor fuels was adopted temporarily and a program of cooperative engine tests was undertaken to ascertain whether or not octane-number determinations by this method correlate with the behavior of widely different types of fuel in representative full-scale aircraft-engines. Should the correlation be unsatisfactory, it is hoped that the results of the engine tests will enable the laboratory method to be modified until it rates diverse fuels in accordance with their average aircraft-engine performance.

The engine-test program is stated, together with the three distinct types of test gasolines and the specifications of the engines used. The reports of the Fuel Subcommittee and the Ways and Means Subcommittee, are included. Other reports are by the Engine Subcommittee and the A.G.D. Steering Committee.

The progress of the tests is outlined. It is stated that it appears possible to complete the test work by April 1, 1935, provided that the participants take immediate steps to do so.

Fuel Injection as Applied to Aircraft Engines by the United States Army Air Corps—*J. F. Campbell, Power Plant Branch, Materiel Division, U. S. Air Corps.*

THIS paper covers in a general way the development of a complete fuel injection system, including fuel injector, discharge nozzle, control system, fuel system, etc., and the application of the system to Pratt and Whitney Wasp engines, Wright Aeronautical Cyclone, Curtiss Conqueror and Allison V-1710 engine, also the installation of the Pratt and Whitney Wasp engine in service airplanes and the performance obtained with the system.

Passenger-Car Bodies Session

Tuesday, January 15

The Practical Side of Planography—*Edgard C. De Smet, Hudson Motor Car Co.*

THE paper supplements the author's previous paper, of which an outline was published in the S.A.E. Journal, Feb., 1934, page 30. The primary motive for the present paper is to analyze this new science from a strictly practical angle and to discuss actual conditions as they now exist in various organizations; also, to offer the new planographic theory as a logical and scientific solution for all irregular-surface problems, with its inherent qualities and advantages of precision, craftsmanship and economy.

The phase of design and engineering considered is that series of operations stretching from the original small sketches submitted by the artist over the entire transition and refinement period, and up to the building of the mahogany forms or "dummies" which are used for the casting and machining of the outside-panel dies.

The author follows through in detail the course of present practice, stating that while the planographic principles are indeed more intricate and require a higher standard of accuracy than the old systems, we have at least succeeded in confining the entire solution of the problem to the drafting room, thus lightening the burden of the shopman and eliminating all uncertainty and resulting delays. Further, he remarks that the ultimate results obtained have been of sufficiently great importance and unusual distinction over previously accepted methods to justify the special descriptive denomination of "Planography" in contrast with the old, common and passive name, "Developments."

Passenger-Car Suspension Session

Wednesday, January 16

The Properties of Tires as Affecting the Riding, Steering, and Handling of Automotive Vehicles—*R. D. Evans, The Goodyear Tire & Rubber Co.*
(Paper published in full, pages 41-49, Transactions Section this issue)

THE principal functions of a tire on an automotive vehicle are: (a) To carry the weight of the vehicle, to cushion it over road irregularities, and to eliminate noise; (b) to provide sufficient traction for accelerating, driving, and braking; and (c) to provide adequate steering control at high speeds.

Adequate steering control, taken for granted in the early days of automobiles, becomes highly important as driving speeds increase. The property of tires whereby steering is accomplished is called cornering power. This power is practically negligible in hard wheels, but is possessed by pneumatic tires due to the extended area of road contact.

Cornering thrust is developed when the plane of the rotating tire makes an angle with its path of travel. The thrust is proportional to this angle up to the point where slippage begins. When a tire is cambered, the cornering force is increased or diminished depending on whether the tire leans "into" or "away from" the curve.

Increase of inflation pressure or of rim width increases the cornering power. Certain structural features of the tire itself affect its cornering effectiveness. However, any change, whether internal or external, which improves cornering power, makes the cushioning ability of the tire worse.

Tread wear continues to be the most important aspect of tire performance. Of the 1934 cars, with various types of springing and of load distribution, some cause much faster tread wear than others. There is also a tendency, as compared with previous years, for rate of wear of front tires to approach that of rears.

Farewell to the Horseless Carriage—*Elliott G. Reid, Guggenheim Aeronautical Laboratory, Stanford University.*

THIS critical study of the possibilities of improving automobile performance and economy by aerodynamic refinement is begun by demonstrating the analogy between motor car air resistance and airplane parasite drag. An example is then cited to illustrate the benefits of aerodynamic research in the latter field and to point out the potentialities of similar work in the former.

Consideration of practical requirements and limitations in an analysis of motor car air resistance leads to the selection of a rear-engine arrangement as the most promising type and to the prediction that its air resistance will approach one-fourth that of conventional cars.

This prediction is confirmed by the results of wind tunnel model tests. Full scale replicas of the models tested would provide adequate passenger accommodations and engine space without exceeding accepted overall lengths. Combination of the test results with reliable rolling resistance data indicates the possibility of reducing current power requirements by 19 to 55 per cent at speeds of 20 to 60 m.p.h.

The author expects rapid obsolescence of the present or "horseless carriage" type to follow the appearance of streamlined, rear-engine motor cars.

Transverse Leaf, Independent Springing—*Karl K. Probst, Consulting Engineer, Leaf Spring Institute.*

THE adoption of independent springing, for the front end, offers the engineer three definite advantages; (*a*) a reduction of unsprung weight; (*b*) the ability to use softer springs, without danger of shimmy, tramping, and other prevalent front-end difficulties; and (*c*) a reduction in transmitted road shocks, induced by single-wheel obstructions. By the use of semi-soft conventional front springs and torque rods, or other anchoring means, the second advantage may be partly overcome. The first and third advantages are inherent with independent springing. The eventual decision, therefore, will probably lie in the comparative durability, weight, and cost of the independent-springing systems, as compared with their advantages.

The subject is treated under the following divisions:

(1) Advantages of independent springing
(2) Drawbacks of soft conventional design
(3) Use of independent springing in volume production; the question of increase in cost and weight
(4) Costs and weight of coil-type independent-springing
(5) The transverse leaf with shock-absorber control is the simplest and cheapest type
(6) The Leaf Spring Institute sample car shows the same ride with coil or leaf springs for the same rates
(7) Correction for spring squeaks
(8) Comparative geometry of coil and leaf-type independent-springing
(9) Comparative ability to hold adjustment
(10) Possibilities of cutting manufacturing cost
(11) Tubular-backbone-frame advantages.

Diesel Engine Sessions

Wednesday, January 16

Cylinder Events Studied in the Logarithmic Diagram—*Alfred T. Gregory, Wright Aeronautical Corp.*

CERTAIN properties of the logarithmic diagram make that type of diagram particularly suitable to the study of cylinder events and to the quick determination of conditions within the cylinder. Although some use has been made of the logarithmic diagram for indicator card analysis this use has been rather limited. Much more can be learned by this means than is usually done.

Not only can valve and combustion events be determined but also cylinder temperatures with and without dissociation and the internal energy of the charge at various points in the cycle can be found. It is thus possible to follow the flow of energy throughout the cycle. A complete picture of the events taking place in the cylinder can thereby be obtained, affording a quick and easy means of studying engine performance.

Examples are given showing the application of this type of analysis to several different kinds of indicator diagrams. These illustrations indicate a wide divergence in maximum temperatures and in residual gas temperatures. Considerable variation is also shown in the heat lost to the cylinder walls during the expansion stroke. The adiabatic exponent for the expansion is seen to be approximately 0.04 smaller than the actual exponent for the two cases in which it was determined.

A Rational Basis for Comparing Diesel Performances —*E. S. Dennison, Westinghouse Electric & Mfg. Co.*

THE paper describes a procedure for analyzing the performance of an internal combustion engine. It is first shown that the characteristics of ideal cycles can be conveniently represented with the help of a fictitious "fuel mean pressure" which is proportional to the useful heat input. The diagram so obtained is used to represent certain ideal Otto and Diesel cycles. It is pointed out that actual performances can be similarly expressed.

A simple correction for the variation of atmospheric conditions is then introduced. Examples from tests are used to show that this correction is in accordance with actual experience. The final form of the proposed diagram embodies the correction.

It is then shown that the performance of a cylinder as it appears in this diagram is a measure of the success of the designer in dealing with factors lying within his control, as distinguished from those arising from the conditions of operation. Therefore, a comparison of divergent designs, of whatever size and type, is possible by representing the indicated performance of each in the manner described.

The friction mean pressure is discussed briefly. The contention is that, while its variation with speed is large, its value at a given speed is practically independent of load.

The procedure of analysis is applied to a group of engines of varied type and size. A wide divergence among these performances is found, and some reasons for the variations are discussed.

In conclusion, a power-characteristic diagram is added, supplementing the preceding analysis which refers to the individual cycle.

Progress Report of Volunteer Committee on Compression Ignition Fuel Research—*T. B. Rendel, Shell Petroleum Corp., chairman.*

THE tendency toward increasing the speeds of Diesel engines has caused them to become more sensitive to fuels and research on the latter has brought out the importance of ignition quality; however, some coordination has been needed for this research in order to develop a standard ignition quality test. In order to escape the difficulties that were hampering the activities of a joint research committee of the S.A.E. and A.S.M.E., a Volunteer Group for C.I. Fuel Research took up the study of fuels in their own laboratories.

Two test methods had been proposed before the formation of this Volunteer Group, the critical compression ratio test and the ignition delay test. The former gave considerable variation; however, the converted C.F.R. engine could not be used for the latter method because of unsteady operation, so a new cylinder was designed. Experiments with the new cylinder, using the delay-measuring method, are in progress. The ignition delay is indicated on the knockmeter, operated by the bouncing pin, a matching test being used similar to the octane number test for gasoline. The result is expressed in the equivalent mixture of reference fuels, cetene and alpha methylnaphthalene, called the cetene number. The delay method appears to be less rapid than the critical compression ratio method, but more accurate.

The program of the Volunteer Group includes improvements in the test procedure and correlation with service engines. Other methods of test will be investigated along with the engine method.

About ten of the new engines are in operation, the laboratories mostly familiarizing themselves with the new equipment. The main difficulty is obtaining steady injection, though no major difficulties appear to be in sight.

Design and Development of Fuel Injection Apparatus for High Speed Diesels—*C. R. Alden, Research Engineer, Ex-Cell-O Aircraft & Tool Corp.*

THE paper discusses briefly but critically some earlier fuel injection systems of the Ex-Cell-O Aircraft & Tool Corp., on which considerable development was expended.

Consideration is given to the influence of various classes of engine service upon the desirable and necessary characteristics of the fuel injection pump. The effect of current trends in the design of small, light weight, high speed engines upon the requirements of the fuel injection system are discussed.

It is clearly shown that universality of application and the practical aspects of maintenance may outrank theoretical advantages. The entire paper recognizes that performance in the hands of unskilled operators will have more weight in determining pump design than the opinions of engineers based solely upon laboratory observations.

Sixteen desirable attributes of a fuel injection system, in addition to the ordinarily well known necessary requirements, are stated.

The design and construction of the Ex-Cell-O fuel injection system is discussed in detail showing the means and manner in which both the necessary and desirable requirements are met.

Particular stress is laid upon non-technical aspects of the fuel injection system, which effect accessibility and ease of parts replacement, availability and variety of parts carried in service stock, and cost of salvaging used precision parts.

Possibility of accomplishing necessary servicing operations with personnel having no knowledge peculiar to "Diesel" engines, or "Diesel" fuel injection pumps, is treated as an absolute requirement of a successful fuel injection system.

Performance data and delivery curves of the Ex-Cell-O pump under various operating conditions are shown particularly with respect to the application of timing control automatically responsive to engine operating speed.

Privately-Owned Airplane Session

Wednesday, January 16

Are We Giving the Average Private Operator the Airplane Most Suitable to His Needs?—*Frank S. Spring, Hudson Motor Car Co.*

ARE we giving the average private operator the airplane most suitable to his needs?

The average private owner is a man between 35 and 45 years of age with an income of more than $20,000 a year. His flying costs, including depreciation of his plane, storage, fuel, service, etc., are approximately $6200 during the two-year period that he keeps a plane.

He makes extended trips throughout the country but they are unusually hurried ones, started with little preparation or study of the route and the conditions he will encounter. His relative inexperience in flying and lack of navigation knowledge subject him, as he flies over unfamiliar routes, to such possibilities as getting lost, flying blind, forced landings, night flying and landing in strange fields after dark, and running out of gas.

Against the abilities and limitations of the average private owner, we should consider the plane that is offered for his use. It will cruise at 125 m.p.h., as compared with 200 m.p.h. for the fastest transports. It lacks the reliability, silence and comfort of transport planes. While it is simpler to handle inasmuch as there is less to watch and to do, and while it will also land and take off from smaller fields, the private owner's plane does not take off as well as the big transports under the same adverse conditions.

To compensate for the private operator, less experienced and skilled, everything possible should be done to make piloting and navigating easier and safer for him. Simplified instruments to aid in blind flying, adequate and trouble-free radio, navigation, landing and radio lights, etc., will simplify his work.

The safety of a plane is dependent upon its reliability, stability, ceiling reserve power and ability to make forced landings over obstacles in an average field. These are factors which should be put into the plane for the average private operator. He will probably prefer a cabin plane to carry four people and ample luggage, at a cruising speed of 200 m.p.h.

While the relative high cost of equipment prevents a wider private use of planes and, on the other hand, the limited production prevents lower prices, it is probable that certain things can be done, as they are being done in Europe, to bring the cost of flying within the reach of a much wider circle. Some of these factors include lighter powerplants, lighter forms of construction, cheaper methods of manufacture, better and more useful designs.

Sales and Technical Problems of Private-Commercial Airplanes—*Peter Altman, Consulting Engineer, Stinson Aircraft Corp.; Director, Aeronautics Department, University of Detroit.*

STATISTICAL data are presented to show the trend in commercial airplane design from biplane to monoplane, and the continuous decrease in the use of open cockpit airplanes for private and commercial purposes. Seasonal sales distribution is discussed and methods are suggested to remedy this condition. The national distribution by states of commercial airplanes follows, in general, the national income and consumption.

Operating records of private and commercial flying are studied. Operating costs are segregated into items of flying and fixed charges. Particular emphasis is given to depreciation and the importance of first cost on the operating expense of an airplane.

Most of the present technical developments for commercial airplanes are not new and data are presented to show that increase in speed has made their adoption necessary for modern airplanes. The importance of the wind tunnel and flight testing in new designs is emphasized.

Available methods to increase speed with a given power are: better streamlining of the whole airplane, with attention to streamlining of

details; retracting the landing gear and tail wheel; improvement of engine cowlings, windshields and fillets. The importance of these items becomes greater as the speed of the airplane increases. The advantages of flaps, air brakes and controllable pitch propellers to improve performance also become more important with increase in speed. The effects of these items on stalling, sinking and gliding speeds; rate of climb; take-off; ceiling and other factors are presented in the form of charts. Photographs accompanying the paper show typical construction of present day private-commercial airplanes.

Air Transportation Equipment for the Private Owner —*John H. Geisse, Chief, Aeronautics Development Section, Bureau of Air Commerce.*

THE author deplores the alleged fact that the aviation industry has been building airplanes for people who purchase them to learn how to fly and has not provided equipment designed to meet the requirements of the individual who desires the airplane solely as a means of transportation by air and is not particularly interested in learning how to fly. He contends that planes for this market need not have controls or flying characteristics similar to existing types. The author points out many of the peculiarities of present type aircraft which make it difficult to learn how to fly and make the safety in flying primarily dependent upon the pilot rather than the airplane. He points out some methods of overcoming these difficulties and lays particular stress on the advantages of the so-called three-wheeled type of landing gear. Comparative data on accidents for scheduled and non-scheduled flying are given to substantiate the contention that airplanes must be made easier and safer to fly for the private owner.

Aircraft Transportation Session

Wednesday, January 16

Operating Requirements for Transport Airplanes—*William Littlewood, Chief Engineer, American Airlines, Inc.*

SAFETY, speed, reliability, economy, convenience and comfort are fundamental requirements of the service rendered by the operator to the user of air transportation. Such phases of these qualities as are properly the responsibility of the transport designer and builder are the subject of the discussion, and suggestions are made for their improvement in the light of experience, and with a view to probable future developments.

Speed is discussed first, being the justification for air transportation. More speed is believed necessary for improved service, operating efficiency and economy.

Safety is naturally considered of prime importance, and is discussed with reference to failures from vibration, necessity for simplification of controls and instruments, and performance characteristics.

Reliability, from the operator's viewpoint, is considered synonymous with durability. Qualifications for continuous dependable service on the line are discussed.

Economy of operation is reviewed with reference to costs of repairs and maintenance. Engine, propeller, tire and brake, and electrical costs are briefly discussed.

Comfort and convenience are treated jointly with reference to numerous details of accommodations for passengers and cargo. Heating and ventilation, noise and vibration reduction, and other matters dealing with the quality of service rendered, are reviewed.

A brief summary of probable future requirements for transport sizes closes the discussion.

Designer's and Manufacturer's Viewpoint on the Requirements for Aircraft Intended for Airline Operation —*J. H. Kindelberger, General Aviation Mfg. Corp.*

ONE of the most essential points in the development of any airplane is the necessity of complete cooperation between the operator and the contractor in regard to necessary and desirable features to be incorporated, and this is particularly important for a commercial transport airplane. This coordination was carried through to a remarkably efficient culmination in the development of the Douglas transport for TWA.

Points discussed include arrangement of cabin and cockpit, seating facilities, upholstery, elimination of vibration, heating and ventilating, soundproofing, toilet facilities, lighting, vision and maintenance.

The care with which all these practical considerations were worked out is discussed, and special emphasis is laid on the important points of soundproofing and maintenance in which a remarkable degree of perfection has been attained. Much credit for the very efficient sound insulation should be given to the Sperry Gyroscope Co., and in particular to Dr. Stephen Zand, who supervised the installation.

This care and attention to details is well worthwhile and only in this manner can a really successful transport be designed incorporating all the technical and practical knowledge of the operator, manufacturer and other specialists who assist in perfecting the various installations.

Supplementary Discussion — *J. L. Atwood, General Aviation Mfg. Corp.*

The recent improvement in the performance of transport airplanes has been effected almost solely by the reduction of parasite drag through careful use of the wind tunnel and by the use of supercharged engines which permit greatly improved altitude performances. In connection with this the technique of operation has been modified chiefly as dictated by aeronautical engineers permitting the full advantages of altitude cruising to be utilized. Other factors contributing to improved performance are the variable pitch propeller and the rapidly increasing use of wing flaps.

Aircraft structural design has been improved permitting the construction of long span cantilever wings rigid enough for high speed operation. The all duralumin metal shell structure now in use combines good appearance and aerodynamical qualities, rigidity, safety in accidents and reasonable cheapness of construction. Structural and detail design are becoming universally good and the chief possibilities for improvement lie in weight reduction and simplification for constructional purposes.

The major possibilities for improvement in speed lie in high altitude cruising which will, undoubtedly, be the next important improvement in transport airplanes. This will necessitate a sealed supercharged cabin and greatly improved engine superchargers, but will be the next step when the economic demand warrants its development.

Fuels and Lubricants Session

Thursday, January 17

Résumé of Research on Oiliness, Conducted on the Sperry-Cammen Adher-O-Scope—*delivered by E. A. Sperry, Jr., Sperry Products, Inc.*

BY measuring the weight in milligrams of oil remaining on the periphery of a metal band after rotating the band at various speeds from 6,000 to 15,000 r.p.m., in a constant temperature of 210 deg. fahr., it was possible to measure the effect of several factors on Adhesion; these included Crude Source, Distillation Methods, Refining Methods, the addition of "oiliness" Compounds, accelerated Laboratory aging, and actual use.

Results of research along this line with the Sperry-Cammen Adher-O-Scope definitely indicate that lubricating oils perform in accordance with their ability to cling to metal surfaces. Measuring this "oiliness" property makes possible the selection of the best lubricants after proper chemical stability and non-corrosiveness have been established.

Quantitatively, within the scope of the tests, oils from Pennsylvania crudes showed higher Adhesion than Mid-Continent, which in turn showed higher Adhesion than Coastal; residuums have higher Adhesion than distillates; super-refinement for high V.I. and chemical stability may seriously reduce Adhesion; additions of small percentages of "oiliness" compounds improve Adhesion materially; and that changes in oils due to use improve Adhesion, but such improvement may be short-lived.

Summary of Replies to Questionnaire of S.A.E. Subcommittee on Oiliness—*prepared by Dr. G. M. Maverick, Standard Oil Development Co.*

THIS serves as a summary report of the data and comments on the question of motor-oil addition-compounds and their effect on engine performance as supplied to the S.A.E. Subcommittee by the different concerns interested in the problem. In all, replies from 23 organizations or individuals were received in answer to the questionnaire circulated Dec. 5, 1934. Of these, 14 commented on items (3) and (4) of the questionnaire, being thus distributed: Automotive, 3; Petroleum, 6; Aviation, 1; and Lubricant Specialty Products, 4.

The automotive concerns reported no advantages realized so far by use of addition products (compounded oils), but have open minds and await conclusive data.

Oil-company engineers are divided, most of them feeling that improved oiliness with compounded oils is reflected in improved engine lubrication; others expressed doubt.

The aviation company replying reported very favorably on compounded oils. No corrosion of bearings was observed and greatly increased bearing life resulted when operation was under extreme test conditions.

Lubricant specialty manufacturers considered that they had evidence

of improvement in service, but did not present data obtained under controlled conditions. Few data in connection with the use of the newer bearing materials were presented by this group.

Opinion on effects on engines, aside from bearing effects, is rather evenly divided, as to whether they are or are not desirable. There is greatest agreement regarding the need for compounded oils during running-in periods on new engines. Some evidence indicates decreased wear and longer bearing life, assuming that corrosion effects do not enter.

Report of Subcommittee of S.A.E. Lubricants Division on Effect of Lubricants on Bearing Metals—*prepared by H. C. Mougey, General Motors Corp., Chairman.*

THIS report embodies comments supplementary to the author's report on copper-lead bearings which he presented at the 1934 Semi-Annual Meeting. Some statements are the result of a questionnaire prepared on behalf of S.A.E. Committees.

The statements indicate that compounded oils are now being sold in commercial quantities. Some such oils and addition agents are believed to have no harmful effect on copper-lead and other newer types of bearings. Others have a detrimental and destructive corrosive effect on certain alloys. Though some compounded oils reduce friction in bearing-test machines, no data have been presented to show this reduced friction in engines. The data are too meager to permit of definite conclusions as to either friction or durability of engine parts.

Commercial bearing-alloys in current production-engines operate satisfactorily with straight mineral oils and do not at present require the use of compounded oils or addition agents. The only conclusive test that will determine the effect test of a particular combination of lubricant and bearing alloy is a specific engine under service conditions. A change in engines or in conditions of operation or in the combination of lubricant and alloys involved may produce different results.

Some combinations of bearing alloys with mineral oils, compounded oils or mineral oils plus addition agents, are satisfactory and others are not. If compounded oils are used, the non-injurious ones should be selected.

Further work is urgently needed to develop laboratory tests that will eliminate a large percentage of the lubricants that are corrosive to bearings, thus decreasing the amount of engine testing otherwise required. Future developments in bearings or engines may make compounded oils necessary, but these oils must be of types not injurious to bearings.

Passenger-Car Brake Session

Thursday, January 17

Hydraulic Brake Actuation—*Burns Dick, Wagner Electric Corp.*

CONSISTENT brake performance becomes more and more essential as average speeds increase. There are conditions under which an emergency application of powerful brakes, not properly balanced, may lead to serious consequences. Many accidents are caused by grabby or out-of-balance brakes, but this is seldom brought to light because the operator is either ignorant of the cause or ashamed to admit it. In other cases, the operator may hesitate too long to apply his brakes when an emergency occurs, knowing that they are out of balance and fearing the consequences of a pivot skid.

For the average passenger car, it is now generally recognized that it is desirable to proportion the braking effect in such a manner that more than 50 per cent is applied to the front wheels.

Correct proportioning—i. e., more torque on the front wheels than on the rear—also corresponds with the more favorable cooling conditions encountered on the forward axle. Tire diameters and wheel sizes are now such, that the brake drums, which should be regarded as "brake heat radiators," are largely hidden in the "shadow" of the tires, instead of being fully exposed to the air stream. The front brake drums, however, are in a much more favorable position for cooling than those on the rear. This is especially true on streamline jobs where tin pants are brought down close to the ground and the body partly shields the rear drums from the air flowing under the chassis.

With hydraulic actuation, the percentage of brake torque on front and rear axles can be accurately and boldly proportioned, with the knowledge that it will maintain the predetermined fore and aft ratio, say 40 per cent on the rear and 60 per cent on the front. This is done by varying the diameters of the wheel cylinders on front and rear axles. Confidence in the constancy of this relation relieves the driver of timidness and allows the maximum possible braking effect to be used when needed.

Brake Drum and Lining Development—*Chris Bockius, Raybestos-Manhattan, Inc., and J. Harold Hunt, Motor Wheel Corp.*

IN this paper, the writers have made no mention of the various types of brakes used in any of the tests, and have endeavored to avoid partiality to any particular type of brake drum or lining, as each fills a particular need which can only be determined by the individual requirements of each car manufacturer.

Brake drums and brake lining must be considered together in present day brake engineering. The manufacturers of both products have found it necessary to carry on extensive development programs in order to improve the performance of their respective products. Test results should not be a matter of opinion, or subject to a wide variation in the personal equation. Therefore, this paper is devoted to a general description of the latest inertia type brake drum and lining testing dynamometers, giving illustrations of both machines and descriptions of the functions of the various attachments, followed by an outline of the general methods at present in vogue for the use of this machine. No attempt has been made to present actual test data, and a general discussion is given regarding the use of the machines at the present time. The discussion leads to but one conclusion—the necessity of exact and thorough evaluation in order that the performance characteristics of drums and lining can be definitely established and classified. This can only be brought about by the development and use of special laboratory equipment such as they have described, which can be relied upon to give consistent data, eliminating the human element and other variables which enter into the various methods of road testing.

Passenger-Car Engine Session

Friday, January 18

Engine Flame Temperatures Vary with Knock and with Position in the Combustion Chamber—*Gerald M. Rassweiler and Lloyd Withrow, Research Division, General Motors Corp.*

TEMPERATURE measurements have been made along three lines through the combustion chamber of a gasoline engine running under non-knocking and under knocking conditions. The results show that, after passage of the flame fronts through portions of the charge located either near the point of ignition or near the center of the combustion chamber, the temperature rises continually until shortly before maximum pressure is reached. When the charge is completely inflamed, there is a temperature gradient along the length of the combustion space, the temperature at the spark plug end being as much as 600 deg. fahr. higher than at the opposite end. These effects are explained on the basis of adiabatic compression and expansion of the gases during the combustion process.

Comparison of knocking and non-knocking explosions shows that in the knocking case:

1. The maximum temperatures are higher.
2. The maximum temperatures are attained earlier in the cycle.
3. The rate of cooling during the expansion stroke is greater.
4. The exhaust temperatures are lower.

Flame Movement and Pressure Development in Gasoline Engines—*Clark C. Minter, consulting chemist.*

COMBUSTION roughness is defined as the ratio of the rise in pressure to the time required for the burning. It is pointed out that evidence shows the time required to burn a charge in an engine is directly proportional to the volume of the charge. A measure of the "natural roughness" of a combustion chamber is given by the ratio of the compression pressure to the clearance volume.

The question of how flame speed varies during the burning is taken up and it is brought out that flame speed goes through a maximum when half the volume of the charge is burnt.

In designing a combustion chamber for smoothness of burning it is necessary to consider the variations in the speed of flame propagation and attempt to bring the maximum speed early in the burning so as to get the flame off to a good start. In this manner it is possible to avoid unduly rapid increases in pressure at a late stage of the burning. This is accomplished by considering the "volume distribution" of the combustion chamber around the point of ignition—a procedure introduced by Janeway. It is thus possible for the maximum flame velocity to occur at any stage of the burning simply by varying the distribution of volume to produce the desired result.

Experience has shown that the point at which maximum flame speed occurs must come early in the burning in order to obtain smooth combustion. The exact location of the point of maximum flame speed will depend on the clearance volume and the compression pressure.

Fuels and Lubricants Session

Thursday, January 17

Report of Cooperative Fuel Research Committee on 1934 Detonation Road Tests—*C. B. Veal, Secretary, C.F.R. Committee; presented at the meeting by H. W. Best, Yale University.*

THIS paper is designed to set forth the important phases relative to motor-fuel detonation of the Cooperative Fuel Research. Ever since the adoption of the C.F.R. Motor Method by the Cooperative Fuel Research Committee on Sept. 12, 1932, periodic checks have been made of the reproducibility of this method. To secure correlation with ratings obtained by this road-test method modifications were made in the laboratory method, which had been evolved by the committee and has been since known as the "research" method. The object of the 1934 C.F.R. detonation road tests, was (*a*) to check the validity of correlation between road knock-ratings and laboratory knock-ratings, and (*b*) to indicate promising paths of research directed toward better mutual adaptation of fuels and engines.

The paper reports on materials and equipment, road-test procedure, supplementary test methods, special reference fuels and results, engine severity-factor and factors affecting fuel-engine relationships. Detonation research is reported upon, and C.F.R. road-test-method specifications are stated in the Appendix.

The Lubricant Requirements of Automotive Worm Gearing—*C. H. Schlesman, Socony-Vacuum Oil Co., Inc.*

THE characteristics of automotive worm gearing have been investigated through the use of a special dynamometer installation capable of testing standard passenger car and bus axles. The equipment employed in the measurement of the efficiency and of maximum permissible torque attainable with various lubricants has been described.

A complete study of the effect of lubricants upon gear performance requires measurement of the rate of wheel tooth wear, the amount and nature of corrosion, and the extent of lubricant oxidation and polymerization, as well as investigation of the rate of wheel pitting. Researches carried out for the purpose of studying the mechanism of tooth fatigue are described, and the results of the study reported.

The conclusion is reached that no single lubricant possesses all of the characteristics desired in worm gear lubrication. It has been found that the product which proves to be the most suitable for one class of service has serious objections when employed under other conditions of operation. The suggestion is made that information relative to lubricant characteristics and the conditions of service to which they are to be subjected, be secured before final selection of lubricant is made.

Production Session

Friday, January 18

What Is Surface Finish and How Can It Be Measured and Specified?—*E. J. Abbott, Research Physicist, University of Michigan.*

THIS paper deals with surface finish from the standpoint of the size and shape of the irregularities which constitute the surface. Profiles of a number of common surfaces have been recorded with an instrument called the Profilograph, and these records can be read directly in inch units. Various machining and finishing operations vary widely, not only in the size of the irregularities, but also in the shape. From this it appears that a single number is not a sufficient specification for a finish when different types of operation are to be compared. Profilograms of several surfaces are shown, and a brief description given of the advantages and disadvantages of several methods which have been suggested for measuring finish.

Surface Integrity and Dynamic Strength—*A. V. de Forest, Associate Professor, Mechanical Engineering, Massachusetts Institute of Technology.*

TO increase the knowledge of this field, the Massachusetts Institute of Technology has established a laboratory for the study of the dynamic strength of materials. It is not always realized that dynamic strength as differentiated from static strength is frequently a matter of the quality of a stressed surface. A crack of insignificant depth, and often totally invisible, will lead to certain failure. Fortunately, a test method has been discovered which will locate such discontinuities, and this is described.

While surface cracks, whether inherent in the metal as in seams or added at the final operation as by grinding, are very dangerous to the life of the part, there are other less known and less easily controlled variables. The chief of these is the condition of surface apart from actual discontinuities.

The new laboratory will attack the problem of the working strength of full-size parts, bringing to bear the special points of view of the physicist, the metallurgist, the designing and testing engineer. A great body of uncorrelated knowledge of the behavior of materials is scattered throughout the literature of these main fields, and a great amount of wisdom lies in the experience of practical men. The new laboratory will serve to focus present knowledge, and add thereto the experimental evidence with which to sift the unknown factors in present practice.

1934 Developments in Cam and Cylindrical Grinding—*Howard W. Dunbar, Manager, Grinding Machine Division, Norton Co.*

REFINEMENT in cam grinding is exemplified by automatic cam grinding machinery recently introduced, covering developments and improvements during the year 1934. The grinding of internal combustion engine camshafts, where the control of shape, finish, limits and performance are vested in the machine instead of skill in its operation.

The paper describes further an interchangeability in design and use of all types of cylindrical grinding machines, this principle of construction being carried to the point where plain machines can be converted to semi-automatic and automatic ones, even after they have been delivered to the customer. Such a high degree of interchangeability is unique in the grinding machine field.

Single Point Boring of Cylinders and Diamond Turning of Pistons—*W. F. Wise, Ex-Cell-O Aircraft & Tool Corp.*

ONE of the problems faced by the production departments of the different engine builders has been the finishing of pistons to specified limits for elliptical and tapered form on the skirt. The Ex-Cell-O Precision Boring Machine makes it possible to reproduce on a high-production scale a cam shape or ellipse and at the same time turn a taper on the skirt, holding the ellipse to within 0.0005 in. of the specified form.

The Ex-Cell-O Precision Boring Machines can be arranged to turn one, two or three pistons simultaneously, with as many different forms if required. On the stationary portion of the machine the motor-driven boring-spindle supports and drives the piston. By means of an hydraulic fixture cam and cam follower, the ellipse and taper are reproduced on the piston.

A new machine has been produced for boring a cylinder block of eight holes in one operation. Four holes are bored in each of two V-blocks at once. The boring spindles are mounted in an angular position and are individually motor-driven. Each of the four spindle brackets is bolted to the slide of the machine and has a horizontal adjustment. The slide on each side of the machine feeds the boring units into the blocks at the same time.

A single-point tool is used for boring, and it is possible to leave 0.0003 to 0.0005 in. of stock in the bores for the honing operation. This not only materially reduces the honing time but increases the uniformity for round and straight bores.

No pains were spared in the design or building of this machine and it is our belief that, with the combination of turned pistons and bored cylinders, a minimum of oil consumption and exceptionally long engine life will result in service.

Modern Resistance Welding in the Automobile Industry—*P. W. Fassler, President, P. W. Fassler & Co.*

THE paper treats the subjects under the following divisions:

(1) The relationship of the automotive and the resistance-welding-machine industry.

(2) Applications of flash and butt welding; projection, spot and seam welding.

(3) The attitude of the automotive engineer toward the welding machine in regard to purchase, application and maintenance.

(4) Clamp and electrode design on body flash welders.

(5) The principles of projection-welding design. The size of the transformer is dependent on the power factor.

(6) The power factor is influenced by the nature of the work, and the design of machine and transformer.

(7) Fixture or bar-welding set-ups.

What Members Are Doing

Dr. Robert E. Wilson has resigned as director and vice-president in charge of research and development of the Standard Oil Co. (Indiana) consequent upon his appointment as vice-chairman of the board of directors of Standard of Indiana's Eastern subsidiary, the Pan American Petroleum and Transport Co. Dr. Wilson, an active member of the Chicago Section and recent speaker at the Society's Regional Meeting in South Bend, Ind., will move his headquarters to New York.

Joining Standard of Indiana in 1922, Dr. Wilson had charge of its chemical engineering research and built up a large engine laboratory for work on fuels and lubricants. In 1929 he was given the responsibility of organizing and directing the development and patent department of the company. He was made a member of the board of directors in 1931, and put in charge of all research, development and patent work.

Earl W. Dilg, formerly chief engineer for the Evans Appliance Co., Detroit, has been named general manager of the Autopulse Corp., Detroit.

Frank C. Mock, associated for many years with the Stromberg Motor Devices Co. and the Bendix Stromberg Carburetor Co., has been appointed vice-president in charge of carburetor engineering of the Bendix Products Corp. In his new connection Mr. Mock will divide his time between East Orange, N. J., and South Bend, Ind.

Wide World

Amelia Earhart

Charles Froesch, formerly sales and service engineer, General Aviation Mfg. Corp., has been appointed to the staff of North American Aviation, Inc. Mr. Froesch is a former vice-chairman for aeronautics of the Baltimore and Metropolitan Sections, and was chairman-elect of the Baltimore Section for 1935 when the impending change in his headquarters caused him to resign. His new connection brings him again to New York.

Charles Froesch

Clyde L. White, former assistant chief engineer, Bendix Brake Co., South Bend, Ind., has been named chief engineer of Linderman Devices, Inc., Detroit.

M. E. Chandler, formerly vice-president of the Bendix Stromberg Carburetor Co., has resigned to become president of a new organization, the Chandler-Groves Co., Detroit. The new organization will engineer and manufacture automotive and aircraft carburetors and other devices. Among Mr. Chandler's associates in the new company will be

Milton J. Kittler, formerly test engineer with the Bendix Stromberg Carburetor Co.

Ronald M. Hazen, project engineer with the Allison Engineering Co., a division of General Motors, has been transferred to the General Motors Research Corp.

Frank H. Pounsett, former chief engineer of Dominion Motors, Ltd., and chairman of the publicity committee of the Canadian Section, has been appointed representative to Australia, New Zealand and the Far East by the Reo Motor Car Co.

N. R. Patterson, former research engineer with the International Harvester Co., has joined the engineering department of Aluminum Industries, Inc., Cincinnati.

Fayette Leister, formerly assistant works manager for the Fafnir Bearing Co., New Britain, Conn., is now manager of the Bearing Appliance Co., Ardmore, Pa.

"First Lady of the Air"

Miss Amelia Earhart (M '30) added another achievement to her long list of "firsts" in aviation when she flew solo recently from Honolulu to Oakland, Calif. The picture shows Miss Earhart looking over her plane at Wheeler Field, H. I., before she took off.

Frederik G. Whittington has joined the MotoMeter Gauge and Equipment Corp., Toledo, as research engineer.

J. Scott McKibben, formerly resident electrical engineer with the Chrysler Corp., has joined the Electric Auto-Lite Co., Toledo, as project engineer.

Thomas Midgley

Thomas Midgley, whose name is associated with many inventions in the pneumatic-tire field, died Dec. 25, 1934, at Bradenton, Fla., where for many years he had been head of the development department, Fisk Rubber Co.

Born in London, England, 74 years ago, Mr. Midgley came to this country and attended public school in Worcester, Mass. In 1883 he became national high wheel bicycle champion. Leaving Worcester in 1884 he joined the Hartman Steel Co. at Beaver Falls, Pa., and remained with that company four years. He operated a business of his own until 1896 when he moved to Columbus, Ohio, and became associated with the Columbus Bicycle Co. Again forming his own company in 1899, he operated it in Columbus until 1905 when he was elected president of the Hartford Rubber Works and was associated with this company until 1914.

The Midgley Tire Co. of Lancaster, Ohio, was formed in 1914 and Mr. Midgley guided the operation of the company until 1917 when he was called to become consulting engineer in charge of mechanical development of the Fisk Rubber Co. of Chicopee Falls, Mass., a position he held until his retirement in 1928.

Mr. Midgley is survived by his wife, formerly Hattie Emerson, whom he married in 1887, and his son, Thomas Midgley, Jr. The younger Midgley is vice-president of The Ethyl Gasoline Corp., and a celebrated chemist.

Both father and son were members of the S.A.E.

Edward C. Blake

Edward C. Blake, president, Blake Motor Car Co., New Rochelle, N. Y., and an associate member of the Society, died Jan. 1 of a heart attack. Mr. Blake had been very active in the social and community life of New Rochelle.

He was born in Pittsfield, Mass., and was associated with the General Electric Co. there during the early years of his working life. Going to Brooklyn, N. Y., he entered the automobile business, establishing himself 16 years ago in New Rochelle.

Frank B. Averill

Frank B. Averill, factory manager for the Studebaker Corp. of Canada, Ltd., and a charter member of the Canadian Section, died Dec. 13, 1934.

Mr. Averill was one of the pioneers in the transportation industry in Canada, leaving the Dominion Carriage Co. in 1917 to join the Gray-Dort Co. at Chatham, Ont.

He went to Toronto in 1921 as general purchasing agent for the old Durant Motors plant there, later becoming factory manager for Durant and its successor, the Dominion Motors Corp.

Properties of Tires Affecting Riding, Steering and Handling

By R. D. Evans
The Goodyear Tire & Rubber Co.

THE principal functions of a tire on an automotive vehicle are: (*a*) to carry the weight of the vehicle, to cushion it over road irregularities, and to eliminate noise; (*b*) to provide sufficient traction for accelerating, driving, and braking; and (*c*) to provide adequate steering control at high speeds.

Adequate steering control, taken for granted in the early days of automobiles, becomes highly important as driving speeds increase. The property of tires whereby steering is accomplished is called cornering power. This power is practically negligible in hard wheels, but is possessed by pneumatic tires due to the extended area of road contact.

Cornering thrust is developed when the plane of the rotating tire makes an angle with its path of travel. The thrust is proportional to this angle up to the point where slippage begins. When a tire is cambered, the cornering force is increased or diminished depending on whether the tire leans "into" or "away from" the curve.

Increase of inflation pressure or of rim width increases the cornering power. Certain structural features of the tire itself affect its cornering effectiveness. However, any change, whether internal or external, which improves cornering power, makes the cushioning ability of the tire worse.

Tread wear continues to be the most important aspect of tire performance. Of the 1934 cars, with various types of springing and of load distribution, some cause much faster tread wear than others. There is also a tendency, as compared with previous years, for rate of wear of front tires to approach that of rears.

FUNDAMENTALLY, driving an automobile consists in maintaining appropriate control over a somewhat complex and ever-changing system of forces. In the last analysis, these forces all center or focus at the areas of contact between tires and road. These areas are the very front-line trenches in the furious battle between space and time. It is therefore appropriate, now and then, as driving conditions change, as speeds increase and as automotive design develops and evolves into new fields and forms, to take stock of the situation; to discover whether the means and mechanism of control of this complexity of forces is keeping suitable pace with the magnitude and relationships of the forces themselves; and to enlighten ourselves, possibly, as to the ways and means for promoting still greater safety and enhanced comfort in our automotive transportation.

Since the tires are so intimately involved in the control of these forces, there is a responsibility on us to determine in comprehensive detail just how the several properties of the tires are related to the problem. It is a purpose of this paper to report some of the recent progress along this line.

The Functions of a Tire

Suppose the question were asked: "What, after all, are the basic reasons for using pneumatic tires on modern automotive vehicles?" We would immediately answer: "To provide cushioning on jolty roads, and to eliminate noise." Then, after further thought, we probably would add: "To provide a large amount of friction between vehicle and road, so that rapid acceleration and deceleration are possible without skidding." Perhaps most of us would stop there. But a more searching analysis would show that the tire has at least one more vital function.

For let us imagine that, through some magic, all our roads should suddenly become perfectly smooth, like plate glass, so that the cushioning ability of the tires would no longer interest us. And further, that all mankind were to lose the sense of hearing, so that noise, even of hard wheels rattling on hard roads, would no longer be comprehended. Finally, assume the existence of some material, rigid, like metal, but having as high a coefficient of friction on our magically smooth roads as does rubber on concrete. Let this material be used for the rims or treads of wheels, so that we could forget about tread wear and punctures and blowouts and other such evils. Would we not then have perfectly satis-

[This paper was presented at the Annual Meeting of the Society, Detroit, Jan. 16, 1935.]

factory rolling equipment? My answer is that we would still have vital need of the pneumatic tire, in order to have adequate directive control of the car. There is no imaginable alternative. Hard wheels would be satisfactory on a wagon pulled by a tongue, or on one guided by flanges. But when the steering is done from within the car itself, only at very low speeds would the hard-rimmed wheel give adequate steering control.

Directive control, then, survives as the one function which can be provided, in adequate amount at present-day speeds, only by the pneumatic tire. The data and discussion presented later in this paper will make clear why this is so. This property of the pneumatic tire has very appropriately been named *cornering power*, and it is probably the most important contribution of the tire maker to the "roadability" of the modern motor vehicle.

However, since our roads are not yet glass-smooth, and since our ears are still sensitive to the roar of hard wheels rolling on hard surfaces, our interest in cushioning is not likely to abate. These two properties, then—cornering and cushioning—are submitted as the two indispensable characteristics of a tire.

Cornering or Cushioning

The sentence just preceding says "cornering and cushioning"; but, when we actually get to working with tires, we find that it is a case of "cornering versus cushioning". Modern tires, of course, possess a certain amount of both these qualifications, but we all know the ever-increasing cry of "more, more". There are various ways in which cushioning can be improved, but each and every one of them makes the cornering worse. In illustration, consider the effect of pressure. We all know that a reduction of pressure improves the cushioning action of the tires. However, their cornering power is correspondingly reduced, so that a pressure is soon reached at which the steering and handling of the car become unsatisfactory.

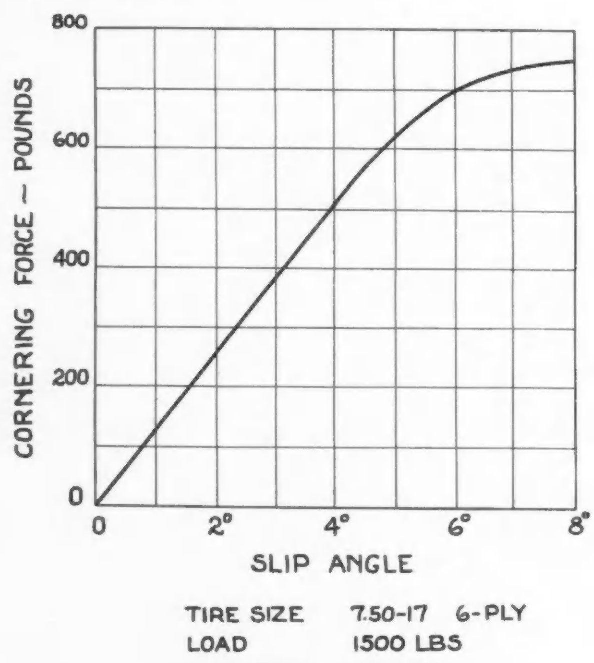


Fig. 1—Illustration of the Manner in Which Cornering Force Depends on Slip Angle

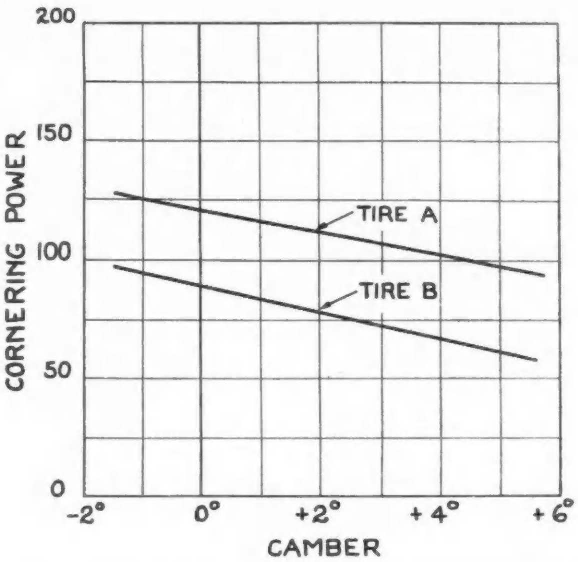


Fig. 2—Showing How Camber Affects Cornering Power

It is always one of the major problems of the tire engineer to discover in what way more cushioning may be "bought" with the least expenditure of cornering "coin". Obviously, good cushioning demands flexibility in the tire structure; otherwise, it cannot conform to the road irregularities. But cornering demands a sort of rigidity or stability in the same structure. These demands are quite analogous to those on an automobile spring, which must be flexible in an up-and-down direction, but as rigid as possible in the lateral direction. The tire designer is therefore confronted with the task of building both rigidity and flexibility into the same structure, as much of each as possible, and then still more. Quite an order!

The "Tire Tripod"—Cornering, Cushioning and Durability.—Underlying these considerations of cornering and cushioning, and obviously of the highest importance to the tire designer, is the ever-present problem of durability. Durability may refer to tread wear, or to carcass deterioration, or to bead disintegration, or to other "diseases", depending on the conditions of service. And just as cornering and cushioning call for contradictory qualities, so are both of them always at odds with considerations of durability. These three factors may be called the tripod of tire performance; any attempt to improve one of them is apt to be at the expense of one or both of the others, and to disturb the level of satisfactory operation. Much of tire engineering resolves itself into a three-way compromise within the limits of this "tripod".

Force Analysis

Let us return now to a more specific consideration of the forces which act between tire and road. We may well begin this analysis by looking at this complex of forces in the manner of the mathematician; that is, by resolving it into certain logical components. Having done this, as simply and painlessly as possible, we shall probably emerge with:

(1) The force between tire and road perpendicular to the area of contact. This force is, of course, the weight of the car, with fluctuations and perturbations thereof caused by road irregularities and the centrifugal effect on curves. This force will hereafter be referred to as the vertical force or as the radial load on the tire.

(2) The force in the plane of the contact area and parallel to the direction of travel. This is, of course, the tractive force involved in accelerating, maintaining speed, or decelerating, and it also includes the rolling resistance of the tire. It will be referred to in this paper as the tractive force, or as the rolling resistance, as occasion requires.

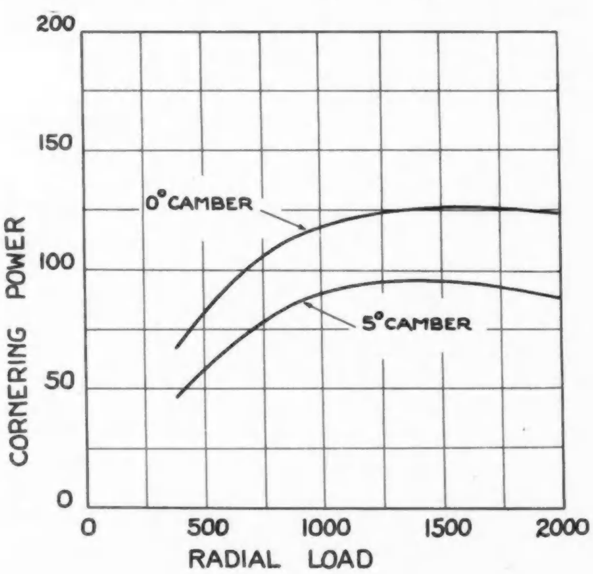
(3) The force in the plane of the contact area, but directed, at each instant, at right angles to the path of travel of the tire and vehicle. We may speak of this as the lateral force, or the cornering force, or as the side load on the tire.

It is obvious that forces (2) and (3) depend ultimately on the existence of friction between tire and road, and therefore can possess magnitude only when force (1) exists. In passing, it is of interest to note that, historically, the automotive world has concerned itself with these three groups of forces in this same order.

First, in the very early days of automotive design, when powerplants were small, speeds low and roads rough, the demand was primarily for a structure which would not collapse under its own weight nor break up under road jolts. Similarly for the tire; it was asked merely to carry its load for a few hundred miles before it, too, cracked up. Who in those days worried about tire noise, or ability to handle tractive effort, or side-sway, or squeal? Who noticed whether the tire gave too much of a grunt as it rolled over an expansion joint?

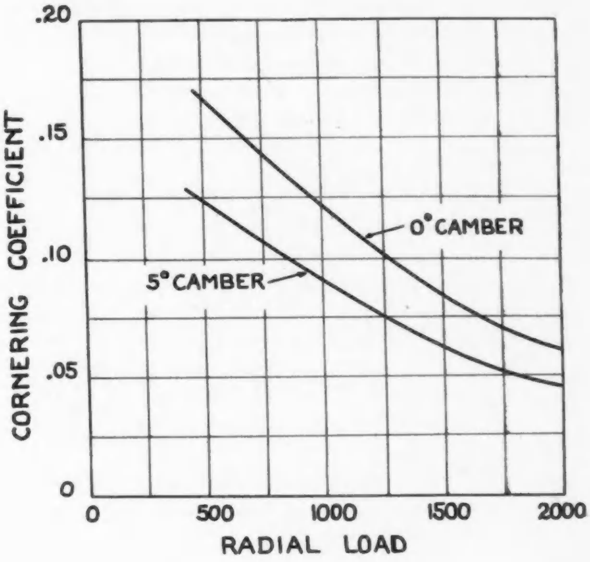
Second, in what we may call the middle ages of automotive history, powerplants were pepped up and quieted down, brakes were improved to handle the increased speed, and smooth hard roads became less of a curiosity. So with the tires; not only were they called upon to stand up structurally, but also to handle the increased tractive duty of faster starting and stopping on smooth roads.

In the third and present epoch, we find ourselves increasingly concerned with the group of lateral forces. Largely because of higher speeds and of the urge to take the curves as fast as the straight stretches, these lateral forces, which maintain the car in a smooth true path, or perturb its motion



TIRE SIZE 7.50-17 6-PLY
INFLATION 30 LBS. PER SQ. IN.

Fig. 3—Curves Showing How the Cornering Power Varies with the Radial Load on the Tire



TIRE SIZE 7.50-17 6-PLY
INFLATION 30 LBS

Fig. 4—Data of Fig. 3 Replotted

with respect to such an ideal path, must be analyzed more searchingly than ever before.

Special Testing Equipment

In the Tire Testing Laboratory of the Goodyear Tire & Rubber Co. a special machine has been installed whereby these several forces may be measured accurately under any desired operating conditions of speed, camber, and orientation. Numerous sizes and types of tires have been investigated under various conditions of load, inflation, and rim mountings. The experimental data now to be presented were obtained with this equipment.

Definition of Cornering Power

Cornering power may be generally defined as the ability of a tire to develop side load or lateral thrust. It is the property of the tire which permits steering around a curved path at speed and, conversely, it is that property which holds the car in a substantially straight path when acted on by incidental lateral forces such as wind.

Cornering force or thrust appears when the tire is caused to roll in such a manner that its plane of rotation makes an angle with the path of advance. This angle, sometimes spoken of as toe-in, is more appropriately called *slip angle.* The manner in which cornering force depends on slip angle is shown in Fig. 1. These values of Fig. 1 apply to a particular size and type of tire under the conditions indicated. The *slope* of the straight part of this line, that is, the cornering force per degree of slip angle, may be called the cornering power of this particular tire. The value of cornering power illustrated in Fig. 1 is 126 lb. per deg. This curve illustrates the typical relationship of cornering force and slip angle. The cornering force is substantially proportional to the slip angle until the latter becomes 4 deg. or 5 deg., then "tapers off".

The initial slope of the curve is practically independent of the texture of the road surface, if it is hard and dry and reasonably smooth. The value of slip angle at which "taper-

ing off" begins does depend to some extent on the road texture; for, as has been pointed out earlier, this lateral force must depend ultimately on the basic coefficient of friction between tire tread and road. In any case, the cornering force appears to have reached its maximum for a slip angle of 9 deg. or 10 deg.

Factors Which Affect Cornering Power

(1) *Camber.*—When a car travels around a curved path, more or less camber of the several wheels is introduced. It is therefore of primary importance to see how camber affects cornering power. Fig. 2 illustrates this effect. Camber is called positive when, in taking a curve, the top of the tire leans away from the center of the curved path. The camber effect may be thought of as a sort of push of the "foot" of the tire sidewise against the roadway, when the tire leans over. This push is added to or subtracted from the thrust due to slip angle, depending on whether the tire leans "into the curve", as in a bicycle, or outward with respect to the curve, as in most of the 1934 cars with independent front springing.

This camber "push" depends not only on the angle of camber but also to some extent on the tire construction. Tire *B* illustrates this point. It is the same sized tire as *A*, and its cornering thrust was measured under the same conditions of load, speed, inflation, and the like. Not only does it have less cornering power than *A* at 0-deg. camber—approximately 72 per cent as much—but the change due to camber is greater. Thus, for each degree of positive camber, *B* loses 5.6 per cent of its cornering power, whereas *A* loses only 4.2 per cent. We have not been able to discover any type of tire construction which will eliminate this camber effect, or reduce it appreciably below the value of tire *A*.

(2) *Radial Load.*—Fig. 3 shows how the cornering power varies with the radial load on the tire. For ranges of load between 50 per cent and 150 per cent of the normal rating of the tire, the cornering power does not change greatly, although there is usually a point of maximum power in the general region of the rated load. This maximum is more sharply indicated when the tire is positively cambered, as is also shown in Fig. 3. However, any benefit implied in this maximum is illusory. For, consider that the usefulness of cornering power is that it provides a lateral thrust which keeps pushing the car around the curve, opposing or balancing the centrifugal effect. The centrifugal effect is of course proportional to the axle load. Hence we should really consider the magnitude of the cornering force in relation to the radial load on the tire; this idea leads at once to the conception of a "cornering coefficient", which may be defined as the cornering power per unit of radial load. The data of Fig. 3 are replotted on this basis in Fig. 4. There is now no maximum point. The principal lesson to learn here is that, the more load a tire carries, the less effective it is as a mechanism for pushing that load around a curved path.

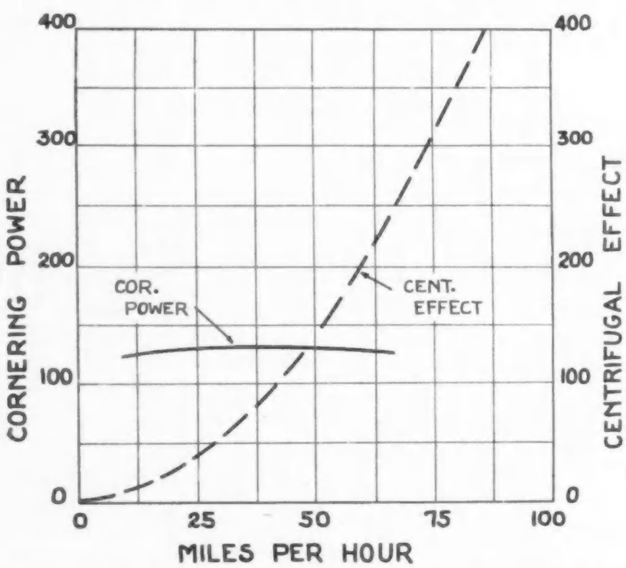


Fig. 5—Showing That Cornering Power Changes only Slightly with Speed

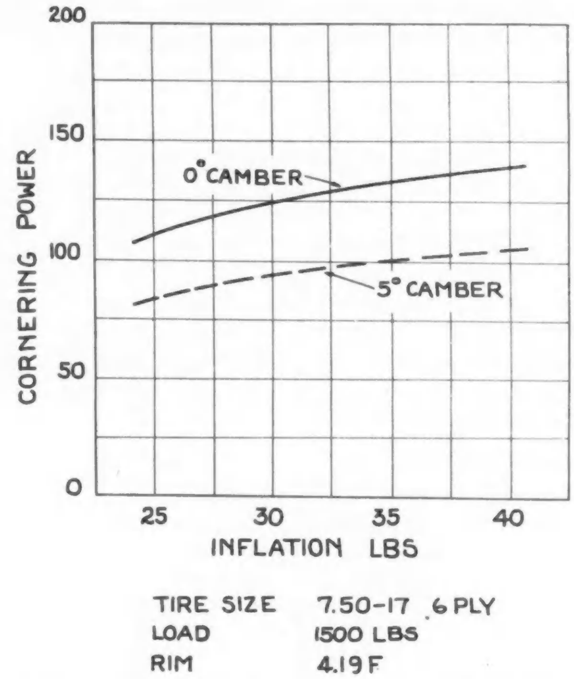


Fig. 6—Showing How Cornering Power Depends on Inflation Pressure

(3) *Speed.*—Cornering power changes only slightly with speed, as shown in Fig. 5. This fact has a very important implication. The centrifugal effect on curves increases as the square of the speed, whereas the cornering power, wherewith we oppose or balance the centrifugal effect, does not increase appreciably with the speed. This is the reason why cornering problems are much more difficult of solution when the speed is high. Thus, a cornering coefficient, which is entirely satisfactory at 25 m.p.h. may be inadequate at 50 m.p.h., and intolerably "tricky" at 75 m.p.h. An attempt to illustrate this comparison also appears in Fig. 5, in which an arbitrary "centrifugal effect" is plotted against speed in the dotted line.

(4) *Inflation.*—Fig. 6 shows how cornering power depends on inflation pressure. The data apply to a 7.50-17 heavy-duty tire. However, for a wide variety of sizes and types of tire, the increase of cornering power is between 2.0 and 2.5 lb. for each pound increase of inflation, in the pressure range between 25 and 35 lb. per sq. in. At higher pressures, however, the effect tapers off, as Fig. 6 indicates. Increase of inflation pressure is, of course, the standard way of getting better cornering action; also, a harder and joltier ride!

(5) *Rim Width.*—The flange-to-flange width of the rim on which a tire is mounted likewise has an important bearing on cornering power. In Fig. 7, this effect is shown for the tire of Fig. 6. Here, again, cornering power improves as the

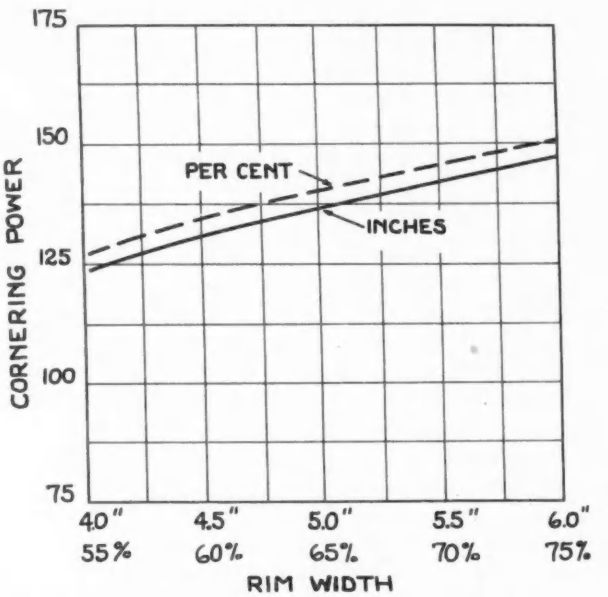


Fig. 7—Showing, for the Tire of Fig. 6, That the Flange-to-Flange Width of the Rim Has an Important Bearing on Cornering Power

rim width increases, but the improvement "tapers off" as the rim approaches the width of the tire itself.

Of course, when the same tire is mounted on rims of different widths, its own width is changed. The wider the rim, the wider the tire. If we express the rim width, not in inches, but as a percentage of the actual side-wall diameter of the tire mounted thereon, we get the dotted line of Fig. 7.

The question immediately presents itself: Is not increasing the rim width a good way to get more cornering power, and what are the limitations and restrictions involved? For one thing, increase of rim width diminishes the cushioning ability of the tire, just as does an increase of inflation. This will be shown more fully in a later paragraph. Hence, the compromise point may well be governed by considerations of tire durability.

The scope of this paper will not permit a complete discussion of the many pros and cons of rim width. Present practice with modern low-pressure tires offers rim widths from 62 to 72 per cent. Too narrow a rim causes more rapid tread wear; one too wide may lead to carcass and bead troubles. There is an optimum point here, which is none too well defined because it depends on the type and proportions of the tire, the operating pressure, and very greatly on the conditions of service.

(6) *Tire Size.*—In addition to the preceding factors, all of which are external to the tire structure itself, several structural features themselves affect this important property. For instance, what about the size of the tire; does a large tire have as much cornering power in proportion as a small one? Consider a 5.25-17 4-ply and a 7.50-17 6-ply heavy-duty tire, both of standard construction and design. These two tires have Tire and Rim Association load ratings of 885 lb. at 32 lb. per sq. in. inflation pressure, and 1645 lb. at 36 lb. per sq. in. inflation pressure, respectively. At these loads and inflation pressures, and on their respective recommended rims, the cornering powers of these two tires are 102 and 138 respectively. The cornering coefficients, as previously defined, are therefore 0.115 for the smaller tire and 0.085 for the larger. Obviously, the smaller tire is far more adequate for the cornering work it has to do. Here is one very important reason why steering and handling large cars at high speed is more of a problem than for small cars.

Also for large, high-speed cars, particularly if one axle load is 20 to 30 per cent greater than the other, the advantage of dual-tire equipment on the heavy end is inescapably obvious. While there are many pros and cons with respect to this proposition for passenger cars, there is no question that large single tires on the lighter end and smaller dual tires on the heavier end constitute the optimum arrangement for steering and maneuvering a heavy car at high speed.

In this connection, it is well to remember that a large tire is not merely a magnification of a small one. In the comparison above, even the most elementary attempt to "similarize" the two sizes would indicate a 23-in. instead of a 17-in. rim diameter for the 7.50 tire. Such an increase of rim diameter would give a somewhat higher cornering coefficient. But in these days, when we go that high into the air for our transportation, we simply take an airplane!

(7) *Cord Angle.*—One of the more important and versatile structural features of a tire is the cord angle. A moderate change in cord angle can profoundly affect many of the performance characteristics of the tire. This is strikingly true of cushioning and cornering. Thus, we find that a 10-deg. increase in cord angle—that is, laying the cord more nearly cross-wise of the tire—gives a very intriguing improvement in cushioning. But, unfortunately, the price which has to be paid in cornering and in durability is impossibly high. An excellent illustration of the "tire tripod"!

Other Tire Properties Involved in Steering

So far, this discussion of the relation of tires to steering control has concerned itself only with forces which directly affect the path of advance of the vehicle. It may now be in order to consider briefly the reaction within the vehicle itself. It is of interest to examine the force or effort required to change the angular relationship between tire and road or

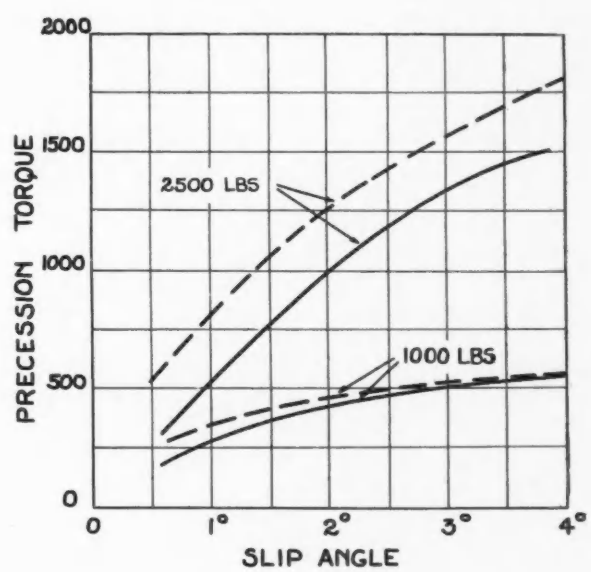


Fig. 8—Values of Precession Torque as Affected by Slip Angle, Radial Load and Camber

path of advance. This effort may be considered under two headings, as follows:

(1) *Precession Torque.*—In the analysis of the forces between tire and road, they were resolved into components corresponding to the three primary directions. Our method of measurement determines the magnitude of the net or resultant lateral force, with which the tire, in cornering, pushes against the road, or against its rim, but we are of course not able to determine just what force each element of the tread is developing at each instant of its excursion through the zone of contact. We may, however, measure the total twisting effort, as well as the net lateral thrust, of this system of elementary forces. This twisting effect has been called "precession torque". It may also be appropriately called "self-aligning torque".

In Figs. 8 and 9 are shown values of precession torque as affected by slip angle, radial load, and camber. The relationships are more complicated than in the case of cornering force, and we have not attempted to work out any sort of "coefficient of precession torque".

This torque represents the real, intrinsic effort of the advancing tire to align itself parallel to the path in which it is compelled to travel. It is the measure of the tire's preference for plain, simple rolling instead of rolling combined with "squirming". Precession torque is of course felt at the steering wheel, when one pulls or holds the car into a fast turn. It is a torque of considerable magnitude, as the scale of Figs. 8 and 9, which is in pound-inches, indicates. This torque, with modern tires at their recommended operating pressures, is sufficient to provide righting action to the steering system even with a large amount of negative caster, especially on hard roads.

Obviously, this property of the tire is sensed by the driver only in terms of steering wheel effort, which also depends very largely on king-pin slant, offset, caster, effective gear ratio, and the various frictions involved in the steering system.

As to relative magnitude, perhaps the most important point about precession torque is the fact that it increases rapidly as the radial load on the tire is increased. This fact is of interest in connection with the steering geometry of cars which carry an increased percentage of the total weight on the steering end.

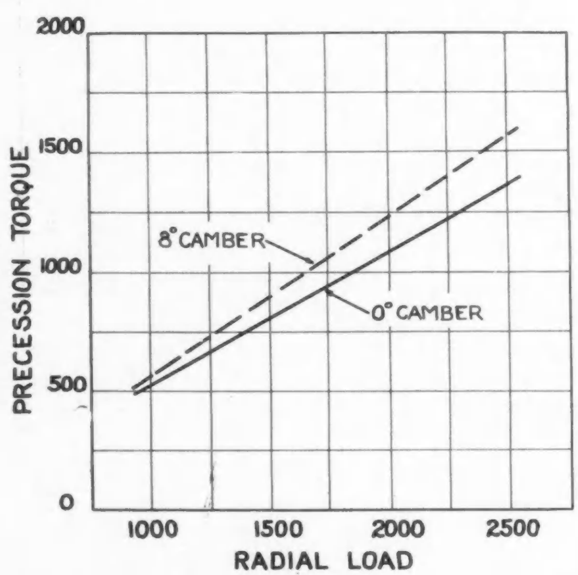


Fig. 9—Values of Precession Torque as Affected by Radial Load and Camber

It is also to be noted that camber increases precession torque. This fact is undoubtedly related to the well-recognized stability inherent in cars with independent front springing. When such a car enters a turn, the front wheels lean outward and the self-righting effect is thereby increased. This is a desirable condition if not permitted to become excessive.

(2) *Static Torque.*—In the same general category as precession torque is another tire property which we may call static or non-rolling torque. It is the maximum twisting effort necessary to twist the tire, standing under load on a level surface, around a vertical axis. This action involves sliding friction, and therefore depends on the texture and condition of the road surface. Fig. 10 shows how this torque depends on the radial load and on the inflation pressure.

If the vertical axis of torque passes through the true center of the contact area, the tire does not rotate on its own axis when its plane is twisted. If the axis of torque is offset, however, then the twisting action is accompanied by a small amount of rotation of the tire. The effect of offset, as well as of camber, is shown in Fig. 11. Positive and negative, as used in Fig. 11, refer to the direction of offset relative to the camber tilt of the top of the tire. This property of the tire is of interest in parking or maneuvering the car at very slow speed. The values given in the diagrams show the intrinsic property of the tire alone, and do not indicate how this effort needed to twist it is modified by particular layouts or arrangements of front end or by efficiency and ratio of steering gear.

Mechanism of Cornering Power

With this wealth of experimental fact at hand we may venture to speculate about the mechanism of cornering power. First, consider a tire rolling along a level roadway under constant radial load, and coerced into traveling with a constant slip angle. Referring to Fig. 12, the contact area of tire against road is represented. In this area the line *AC* is parallel to the plane of rotation of the tire. The line *AX* is parallel to the path of advance of the tire. The angle between these two lines is, of course, the slip angle.

Let us consider the history of an element of tread as it enters, passes through, and makes its exit from the contact area. Entering at *A*, the tread element is immediately grasped by two divergent forces: One is the friction of the road which tends to freeze this element to the same spot until it is released at the moment of exit from the contact area. The effect of this force would be to make the tread element follow the path *AX*. The second force is the lateral rigidity of the tire which tries to make the tread element follow its natural path *AC*. As long as the friction force prevails, the tire is distorted by an amount represented by *CX* and feels a thrust from the road in that direction. This thrust, totalized for all the tread elements occupying the contact area at any instant, constitutes the cornering force of the tire. From this analysis we may draw four conclusions:

(1) The upper limit of cornering force is determined by the available friction which, in turn, depends on the coefficient of friction, the unit pressure, and the radial load.

(2) The magnitude of the cornering force depends on the lateral rigidity of the tire structure under the conditions of radial deflection which obtain.

(3) The cornering force depends on the amount of distortion of the tire. This distortion is represented by *CX*, which is approximately proportional to the slip angle and to the *effective length of the contact area.* It is obvious that

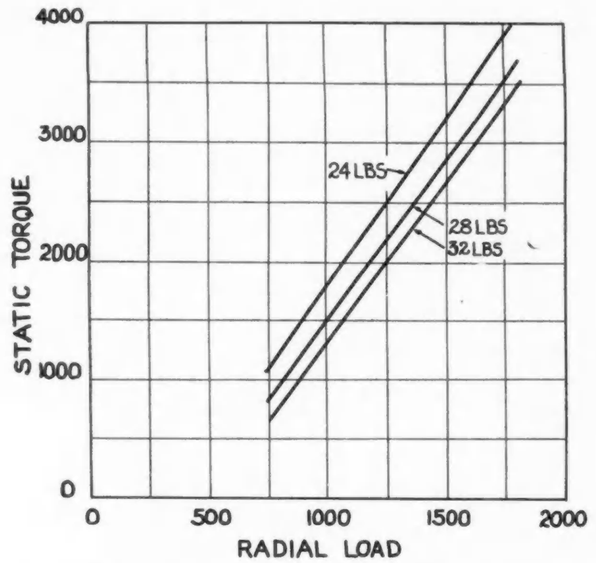


Fig. 10—Showing How Static Torque Depends on the Radial Load and on the Inflation Pressure

the totalized cornering force is roughly proportional to the square of this length.

(4) This analysis indicates that cornering power should depend very little, if any, on speed. Fig. 5, previously referred to, is confirmation of this point.

Item 1 is easy to accept if we will just recall our steering experiences on wet, slippery roads. As to item 2, experimental determinations of lateral rigidity of a wide variety of tires, under various conditions of load, inflation, rim width, and the like, show a close parallelism with cornering-power data.

In item 3, the term *length of contact area* merits close attention. Herein lies the important difference between a pneumatic tire and a hard rigid wheel. If a tire is to have cornering power, it must be capable of considerable radial deflection in order that there may be an adequate length of contact area against the road. This means that our tire must be radially flexible. At the same time, the tire structure must be as rigid as possible against lateral distortion. It is these two contradictory requirements, which must be met in the same continuous structure, that make the tire designer's problem so extraordinarily difficult.

By contrast, a hard-rimmed wheel—as in the imaginary case discussed previously—is very rigid and practically inflexible in a radial direction. Hence, when it presses against a hard road, the area of contact will have negligible dimension in the fore-and-aft direction. Thus, even though the hard rim is very rigid laterally, and no matter how large the slip angle may be, it is impossible for a hard-rimmed wheel to develop a large cornering power or cornering coefficient.

Cushioning Power

So far in this discussion we have confined our attention to the group of lateral forces. Space forbids an equally extended analysis of the other two groups. There is point, however, in giving brief consideration to one aspect of the vertical force, or radial load on the tire. The radial load carried by a tire is always a matter of paramount interest because of its direct relation to durability. We are also concerned with the perturbations of radial load because cushioning ability relates directly to these perturbations.

The term cushioning ability or power has been heretofore used with no attempt to explain or define it more precisely. Cushioning action of a tire depends on its ability, in rolling over an obstacle or road irregularity, to absorb or envelop it with the least possible delivery of additional force to the rim and wheel. It is the kind of thing which cannot be evaluated completely, but for which an arbitrary index can be set up. We may set up such an index by selecting some obstacle, such as a cleat, and rolling the tire over it very slowly under constant load. The maximum rise of the axle is measured. It may be assumed that the impact or jolt delivered to the car when the tire rolls at speed over a similar obstacle on the road is more or less in proportion to this slow-motion constant-load value of axle-rise. Axle-rise may be measured under all desired conditions of load, inflation, rim, cord angle, and the like, and becomes an inverse index of cushioning power. It is important to keep in mind that it is merely a trend-index on an arbitrary scale, and not a measure or coefficient.

One diagram, Fig. 13, will suffice to show how this index may be used in examining the relative effect of various factors on cornering and on cushioning. Thus, increasing rim width from 5.0 to 6.0 in. increases the cornering power as much as a 5-lb. per sq. in. increase of pressure. The same increase of rim width, however, increases the axle-rise index as much as only a 3-lb. per sq. in. increase of pressure. In other words, if rim width is increased to gain cornering power, the price paid in loss of cushioning is not quite as great as if inflation pressure is increased.

Tread Wear

Since tread wear continues to be the most important aspect of tire performance, all factors which have a possible bearing on the rate of tread wear merit the closest scrutiny. The year 1934 has witnessed faster pick-up, still higher driving speeds, snappier brakes and braking; also a general increase in the weight of vehicles. Weight distribution has been greatly changed, and tire pressures, particularly on front wheels, have been substantially reduced. Means of controlling the front wheels have been developed which make it feasible to handle cars with these low front tire pressures without troublesome results as far as the driver is concerned.

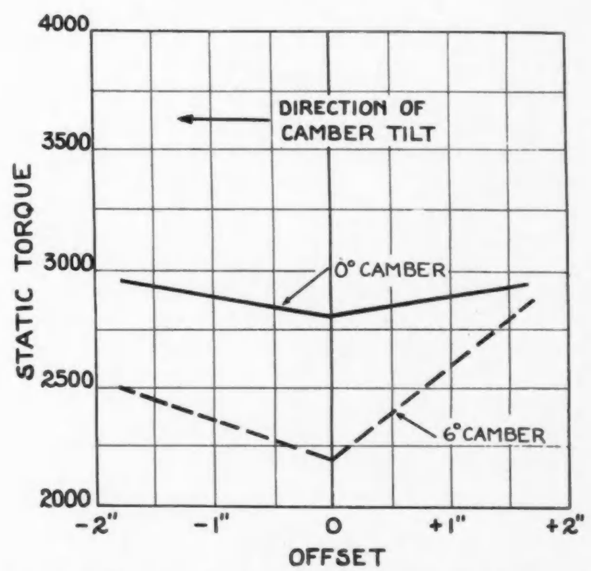


Fig. 11—Showing the Effect of Offset and the Effect of Camber

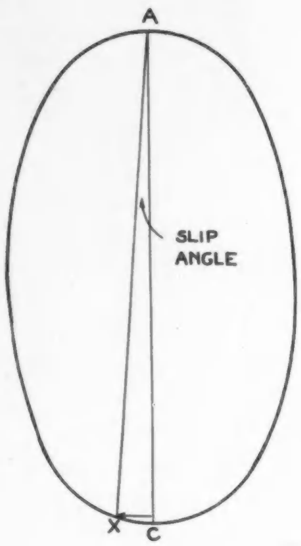


Fig. 12—Illustration of a Tire Rolling along a Level Roadway under Constant Radial Load and Coerced into Traveling with a Constant Slip Angle

For reasons of safety, road builders are making road surfaces more non-skid and hence very much more abrasive. This is true of renovated roads as well as of all types of new construction.

Finally, over much of the country we have had a long, hot, dry summer, which has contributed its share towards the unusually rapid tire wear which has been generally experienced.

It is of the greatest importance that we segregate, as far as possible, these various factors, and fairly and open-mindedly evaluate their respective places in the tread-wear picture.

During the last year, the Goodyear Tire & Rubber Co. has conducted a large number of tread-wear tests. These tests have involved numerous makes and sizes of cars, all new 1934 models, and all maintained at the highest possible level of condition, not only as to engine and transmission features, but particularly as to brake equalization and front-end alignment. These tests, set up primarily in connection with tire-development problems, have been so organized that a considerable fund of information of more general interest has become available. In the comparisons to follow, all factors other than those being compared have been properly and scientifically eliminated. All comparisons, which are direct and not "second hand", are given in terms of ratings. These refer to the relative mileage of the tires up to the "just-smooth" stage.

(1) *Front versus Rear-Tire Wear.*—The following tabulation shows the relative mileage of front and rear tires as affected by independent springing and also by extra braking. Each comparison is the average of a number of separate tests, involving different cars of the types indicated. The front and rear tire pressures are in accordance with the respective manufacturer's recommendations.

Type of Front Suspension	Periodic Brake Application	Relative Mileage Rear	Relative Mileage Front
Conventional	No	100	135
Independent	No	100	117
Independent	Yes	100	96

Of course, these ratings depend on tire pressures, weight distribution, and distribution of braking, but they also depend to an important extent on the particular geometry and structural flexibility of the front suspension and of the steering system. They also depend on the type of road, both as to surface characteristics and the prevalence of curves and grades.

(2) *Front-Tire Wear.*—Front-tire wear, as shown in the preceding tabulation, is the average of both left and right tires. There seems to be a consistent difference between the left and right front-wheel position. This difference apparently is related to the type of front springing, as shown in the following tabulation:

Right versus Left Front-Tire Wear

Type of Front Suspension	Relative Mileage Left Front	Relative Mileage Right Front
Conventional	100	94
Independent	100	83

These figures represent the averages of several individual comparisons in each case. The reason for this difference has not been definitely determined. Whether it is road crown, the tendency for more loose, abrasive material to be on the right side of the road, the habits of drivers in taking left turns faster than right, or some other factor or combination of factors, is not known. We have shown, however, that it is *not* due to a difference of load. With an independently sprung car loaded exactly the same on right and left front wheels—the driver, of course, included—the right front mileage was 86 per cent of the left. Another test with this same car showed that front tires inflated to 22 lb. per sq. in. give only 70 per cent of the tread mileage of tires carrying 28-lb. per sq. in. inflation.

(3) *Tread Wear of Various Cars.*—It is a tradition in the tire industry that rate of tread wear varies considerably for different makes and types of cars. As for the cars of 1934, with their numerous departures from chassis designs previously more or less standard, these traditional differences of tire wear seem to be accentuated.

The following tabulation contains a limited amount of testimony in this connection. Again it may be emphasized that these comparisons contain no factors affecting rate of wear, other than the cars themselves and those specified in the column headed "Remarks".

Car	Type of Front End	Tire Position	Extra Braking	Relative Mileage	Remarks
A	Conventional	Front	Yes	100	Load penalizes
B	Independent	Front	Yes	75	Car *B* slightly
C	Independent	Rear	Yes	100	All test condit'ns
D	Independent	Rear	Yes	146	identical
E	Conventional	Rear	No	100	Car *F* penalized
F	Independent	Rear	Yes	115	by extra braking
G	Conventional	Rear	No	100	Relative load fa-
H	Independent	Rear	No	67	vors Car *H*
I	Conventional	Rear	Yes	100	All test condit'ns
J	Independent	Rear	Yes	100	identical
I	Conventional	Front	Yes	100	All test condit'ns
J	Independent	Front	Yes	61	identical

Fleet Operation

As a further contribution to the tread-wear picture, we may cite the results of a recent cross-country trip of part of the Goodyear Test Car Fleet. Nine cars made this trip together. Five of them had independent suspension, four had conventional axles. All nine were new cars, four-door sedan

models, with 1000 to 1200 miles of break-in running before starting the trip, and all were in the best possible condition of brake adjustment and front-end alignment.

Each car was equipped with regular production tires of original equipment specification. Pressures were set at the recommended values at the start of each day's trip, and checked several times during each day's run. Front and rear pressures were the same. Each car was driven by two drivers, alternating morning and afternoon. Also each car carried the standard three-passenger load.

Throughout the trip the weather was bright and moderately warm. All driving was in the daytime, with a 400-mile daily average for the 2400-mile trip. The cars traveled close together, at a cruising speed of 60 to 65 m.p.h. The average speed for the trip was 42 m.p.h. The average speed for one of the cars (see following tabulation), used by the fleet commander, was about 6 m.p.h. faster than for the others.

At the end of the trip, the tread-wear of each of the 36 tires was carefully measured and analyzed.

The results are given in the following tabulation, in the form of ratings. As before, these ratings give the relative mileage to the smooth stage, based on the assumption that the same relative rates of wear would continue.

The column headed *LF/RF* gives the ratio of left front to right front mileage for each car; the next gives the same for the respective rear tires. Then appears the average of the rears compared to the average of the fronts. These columns will repay detailed examination, which will not be attempted here.

Under "Relative Ratings of Cars", the first column, *F*, refers to the front tires. Car *Q* had the slowest wearing front tires, so it was rated 100. The others fall below this in relative mileage rating, down to the case of Car *M*, with a rating of 42. Similarly for the column *R* referring to rear tires. Car *L* showed slowest rear tire wear, and was rated 100. Again Car *M* was lowest, with 63.

Finally, the last column gives the average rating, combining the front and rear ratings. Now Car *R* makes the best showing. It is therefore rated 100, with Car *M* at the foot of the class with a 55.

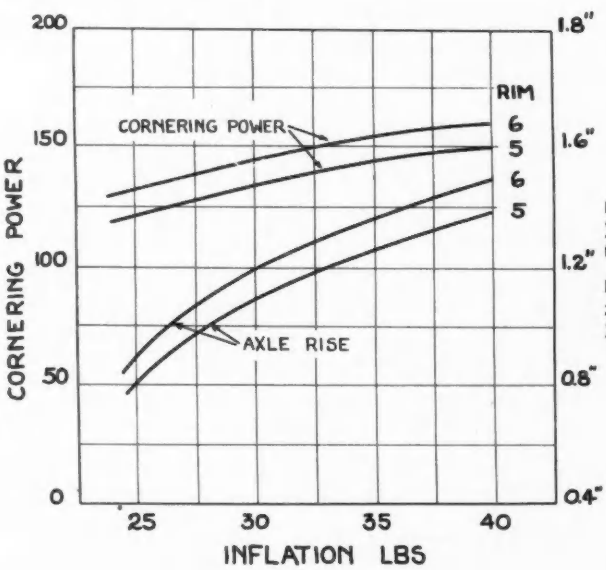


Fig. 13—Showing How the Trend-Index May Be Used in Examining the Relative Effect of Various Factors on Cornering and on Cushioning

					Relative Ratings of Cars		
Car	Type of Suspension	*LF*/*RF*	*LR*/*RR*	Aver. *R*/Aver. *F*	*F*	*R*	Average
K	Independent	100/83	100/103	100/140	62	86	77
L	Independent	100/73	100/96	100/88	45	100	76
M	Independent	100/64	100/88	100/128	42	63	55
N	Independent	100/91	100/112	100/135	53	74	67
O	Independent	100/95	100/114	100/188	73	75	77
P	Conventional	100/89	100/121	100/190	80	83	85
Q	Conventional	100/70	100/100	100/242	100	80	94
R	Conventional	100/102	100/112	100/189	94	97	100
*S**	Conventional	100/90	100/88	100/175	70*	78*	77*
Average	Independent	100/80	100/103	100/136	55	80	68
Average	Conventional	100/88	100/105	100/194	86	85	85
Average	All	100/84	100/104	100/164	..	..	..

Group Average: $\frac{\text{Conventional}}{\text{Independent}} = \frac{100}{80}$

*Car *S* was used by fleet commander. Its average speed was approximately 6 m.p.h. faster than the rest of the fleet.

Conclusions

These results on tread-wear are not submitted as a basis for sweeping or general conclusions, or as proof that some particular feature of chassis design is necessarily unfavorable to satisfactory tire service. No claim is made that these ratings would be paralleled in general field experience. The purpose in presenting them is merely to emphasize the wide range of conditions under which satisfactory tire-performance is demanded.

However, we cannot ignore these indications that chassis modifications and developments have an important bearing on tire performance, just as a definite balance or compromise of tire properties is necessary for the satisfactory operation of the automobile. Let us fully and clearly recognize our joint responsibility in analyzing and evaluating all factors and aspects of this problem.

It is hoped that this paper may contribute, if only in a slight degree, to a better comprehension of some of these factors.

Current Problems in Airline Engines

By R. F. Gagg
Assistant Chief Engineer, Wright Aeronautical Corp.

AN outline of some current problems in aircraft engines with particular reference to the types used for main-line scheduled-transport operations is presented, it being limited so far as possible to a consideration of the conventional four-stroke gasoline-engine.

Types of airline service are considered and, as regards engine sizes, it is remarked that airline service demands engines in a range of sizes from the maximum available to about 250 hp. as a minimum.

Statistics of the present performance of airline engines are given, and it is stated that the horsepower output required to meet the contemplated schedule with the most adverse wind normally expected on the route is a nearly correct measure of the true effective size of the airline engine; further, that its durability and performance should, in general, be judged on that basis.

The importance of fuel consumption is stressed. As to preliminary tests of the hypothetical engine discussed, a dynamometer calibration of the sea-level performance-characteristics—which should be extended to cover altitude operation also if the necessary equipment is available—should be made.

Data on cylinder cooling are presented. and lubrication and other problems—such as compression ratios, fuels, supercharging and mixture-strength control at altitude—are treated.

THIS paper is intended to be only an outline of some current problems in aircraft engines with particular reference to the types used for main-line scheduled-transport operations. It is further limited, so far as possible, to a consideration of the conventional four-stroke gasoline-engine, thus eliminating consideration of the possible development of some startling new type which may sweep away overnight all of the problems and troubles which now cost us so much work, worry and wealth. (We freely admit that the wish is father to the thought.)

[This paper was presented at the Dec. 10, 1934, Meeting of the Metropolitan Section of the Society.]

The experience of the last 10 years of airline operation has gradually developed several distinct types of aircraft designed for specific operating conditions. Originally, any available kind of flying machine was considered suitable by most of the optimistic pioneers who established the forerunners of our present dependable services, but now it is difficult to obtain satisfactory performance and achieve a minimum of loss on airline operating-costs without specialized equipment.

Types of Airline Service and Engine Sizes

Originally, the small engine completely filled the airline picture because it was the only kind available; moreover, the size was not ill-suited to the service required at that time. The recent development of long-haul limited-stop service has accentuated the trend toward larger engines until practically the only place where engines of less than 350-hp. rating now find application in airline operation is in branch-line and main-line local-service where frequent stops and relatively small loads virtually require the use of small airplanes. These engines, in general, do not require supercharging for high altitudes, because the short distance between stops makes low-altitude cruising both faster and more economical. It seems probable that a large increase in this class of service will shortly occur, and thus provide a fresh impetus to the improvement of engines of about 300-hp. rating.

For the limited-stop main-line services the present trends will probably continue, with an increase in the actual practice of cruising at altitudes above 12,000 ft. It seems strange that some airline operators should pay all the penalties—and they are many—of choosing engines suitable for 15,000-ft. cruising, and then utilize none of their advantages by normally operating at relatively low altitudes. As this folly disappears, there will become evident a need for improved take-off and climbing ability without sacrifice of high-altitude performance-characteristics. Probably there will be a continued demand for some engines of 400 to 600-hp. rating for use in long-haul main-line service where the volume of traffic does not warrant the use of large airplanes, though present trends in the growth of through-traffic appear to indicate that the largest available engines will continue to dominate this field.

The same considerations which favor the use of large engines for long-distance overland-travel become imperative in the consideration of transoceanic routes. The growing demand for this service cannot be answered in a thoroughly satisfactory manner until there is available a suitable engine of at least 1000-hp. rating. However, the problem is not as simple as we might wish for, and an answer is not immediately at hand.

This hasty glance indicates that airline service demands engines in a range of sizes from the maximum available to about 250 hp. as a minimum, which immediately raises the

Table 1—Present Performance of Airline Engines

Maximum power available for take-off, hp. per cu. in.	0.38 – 0.42
Power in protracted climb near sea level, hp. per cu. in.	0.36 – 0.40
Maximum power at the critical altitude, hp. per cu. in.	0.38 – 0.42
Critical altitude, ft.	6000 – 8000
Power for continuous cruising, hp. per cu. in.	0.25 – 0.30
Piston speed for continuous cruising, ft. per min.	1750 – 2000
Operating altitude, ft.	12,000 – 14,000
Fuel consumption for continuous cruising, lb. per hp-hr.	0.48 – 0.54
Specific weight at cruising output, lb. per hp.	2.0 – 2.5
Service between shop overhauls, hr.	300 – 400

question of how many different sizes are required. It is suggested that the following series would provide ample choice in horsepower ratings without undue complication; that is, 250, 320, 400, 500, 640, 800 and 1000.

Present Performance of Airline Engines

Before proceeding further in an examination of where we are going, or rather, why we are not going faster, it seems in order to locate just where we are now as a sort of datum point or landmark. Current service-types of American air-transport engines in normal routine operation generally show performance characteristics approximately as indicated in Table 1, though somewhat better values may be obtained under the most favorable conditions. The values shown are believed to be fairly representative of current practice, and are presented with pride and penitence in the appropriate spots.

The recent trend of changes in some of the performance characteristics of the larger engines is roughly outlined by the curves of Fig. 1. While the data are plotted against time as abscissas, the improvement in engine performance is, unfortunately, no direct function of time. If that were true, we should merely wait very patiently for 16 months for the scheduled arrival of the solution of our most vexing problem. The curves give the impression that we are working in a region of diminishing returns where effort spent on conventional types of engines will be less gainful than in the past. This is an incomplete picture, for the margin of possible improvement has by no means been exhausted, and in a favorable economic situation it seems possible that further startling gains may actually be realized, though to venture precise predictions for any long period is certain folly.

Basis for Selection of Engines

Until very recently, the selection of an engine for an airline-transport installation has largely been based on consideration of maximum power-output, reliability, useful life and purchase price. The last item, a matter of relatively small importance, need not be considered here. A reasonable demonstration of dependability is a prerequisite of the licensing agency, and experience with similar products under actual operating conditions is justly a major influence in these matters. However, the maximum possible performance is not an extremely important consideration so long as the demands of emergency service can be met in a satisfactory manner.

If the contemplated operating schedule calls for a speed of 200 m.p.h., it would appear to make but little difference whether the maximum possible figure were 225 or 235 m.p.h. or whether the airplane ceiling with one inoperative engine is 3000 or 5000 ft. above the maximum ground elevation on the airline route. It is conceded that a large margin of reserve power is an important asset, but whether this margin should be 30 or 33 per cent is difficult to decide without being able to predict accurately what emergencies may be encountered, aside from failure of one engine during take-off and the like.

The horsepower output required to meet the contemplated schedule with the most adverse wind normally expected on the route is a nearly correct measure of the true effective size of the airline engine, and its durability and performance should, in general, be judged on that basis.

Importance of Fuel Consumption

In the evaluation of an engine for some specific set of conditions, it has now become common practice to consider the weights of propeller, engine, cooling apparatus, installation, fuel-and-oil load as the total propulsion weight. This concept becomes increasingly important as the flight range grows, and the figure of merit is, of course, the number of hours obtained per unit of weight, assuming that the value for cruising horsepower and the operating altitude have previously been determined. The important effect of the specific-fuel-consumption value is illustrated for a sample case in Fig. 2. It will be observed that a 15-per cent increase in the weight of the basic engine—represented by the width of the bottom line—is of less importance than a change in fuel consumption of 0.10 lb. per hp.-hr. for a flight of no more than 3 hr. For a flight of 10 hr. or more, the effect of the increase is almost insignificant.

When interpreted in terms of net payload, or as a decrease in size and power for a given payload for long flights, it is apparent that the fuel consumption obtained while cruising is a governing consideration. Its importance is still further magnified when counting the effects of fuel reserve, total

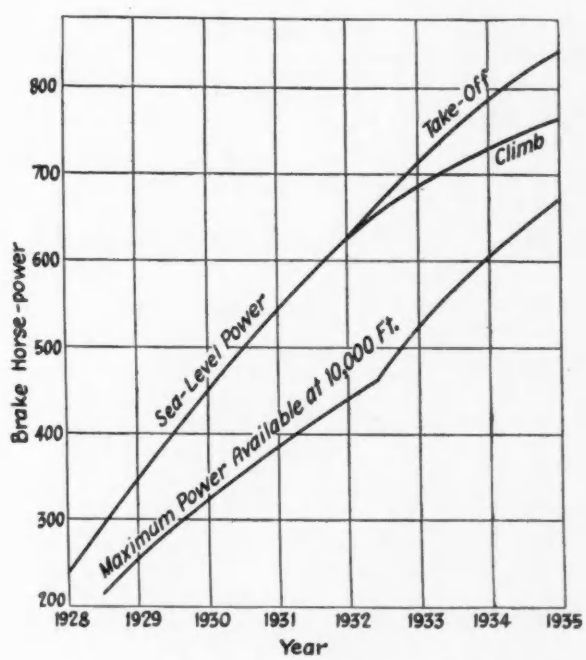


Fig. 1—Recent Trend of Changes in Performance Characteristics of the Larger Engines

structural weight, wing area, drag, and the like. A consideration of present results obtained from most currently accepted types indicates that material improvement is in order.

Preliminary Tests of a New Engine

The fuel-consumption problem is so intimately connected with horsepower characteristics and cruising ratings that neither can be considered alone. Assume for the moment that we are presented with a new model of an engine of conventional type, and that it is necessary to select maximum-output and cruising-operation ratings for optimum results on an airline faced with keen economic competition. Take it for granted that it is a well-balanced design, and is stressed for operation at speeds and loads a little in advance of current practice.

For present purposes, we may dispense with the painful preliminaries of determining the excess of weight above the estimated value, rush photography for the advertising man, and the like, and proceed to a dynamometer calibration of the sea-level performance-characteristics which should be extended to cover altitude operation also if the necessary equipment is available. Having thus completed the preliminary testing of our modern, though hypothetical engine, without having suffered any hypothetical major casualties, we are now ready to consider the real difficulties almost sure to be encountered, together with possible solutions for these troubles. After they are disposed of as best we may, we shall need to conduct adequate endurance-tests and some flight tests before establishing the rating for airline service.

Cylinder Cooling

There is no great difficulty in direct air-cooling at a specific power-output representative of current cruising values of not more than 0.30 to 0.35 hp. per cu. in., provided that complete baffles are used and the cowling is constructed in accordance with the best current practice. However, trouble probably will be encountered in the condition of climb at maximum

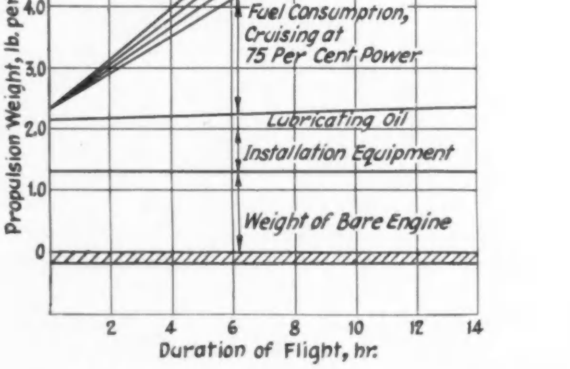


Fig. 2—The Important Effect of the Specific-Fuel-Consumption Value as Illustrated for a Sample Case

power-output. Experimental work is now in progress to determine definitely the boundaries of satisfactory operating conditions with the object of tentatively establishing standardized conditions under which satisfactory operation should be obtainable with good engine design and good cowling. This involves measurement of the quantity of air flowing over the cylinders—a relatively simple procedure in the laboratory—the development of means for empirically duplicating this determination in flight for the design of baffle being used, and modification of the baffles to obtain an optimum result with a minimum quantity of cooling air.

The measurement of airflow through the baffles in flight is difficult because of the turbulence and whirling of the airstream behind the propeller. Several ingenious means for the experimental determination of these effects have been devised, and it is now believed that reasonably satisfactory results can be obtained from differential pressure-measurements made at the throat of the baffle.

Some interesting data on the temperature levels over the cylinder structure have been obtained as a sort of by-product, and a sample set of readings is shown in Fig. 3. In this case, the combustion-chamber temperatures are measured 1/4 in. from the inner surfaces of the metal. The power output was not particularly high at the time the readings were obtained, the cooling-air flow being restricted to reach the levels shown. Though tests at low air-temperatures have not yet been completed, the data thus far available indicate that, if all other conditions are held constant, the cylinder temperature varies almost directly with the cooling-air temperature in the range below 130 deg. fahr.—for non-detonating operation—and that the horsepower output does not vary appreciably. This is illustrated in Fig. 4. This agrees with the hypothesis, which states that the only deviation from a linear relation is due to the effects of a change in radiation due to the higher temperature-level. It is hoped that we shall soon be able to establish standards for air-cooling conditions which will give definite, satisfactory results in place of the present uncertainties.

Lubrication

The second serious difficulty encountered in the testing of our hypothetical engine is that of lubrication. The rated speed results in an average piston velocity of about 2400 ft. per min., and this gives a rather high unit-loading on the bearings. In spite of the fact that the best advertised oil is being used in the engine, the bearings persist in showing bright spots and cracks in the material of the liners. This is most annoying, and a conference of experts decides that both the oil grooves—or lack of them—and the bearing material are at fault. Someone computes the *PV* factors and shows that they are all wrong when judged by the published standards. The lubricant people solemnly aver that the oil meets specification requirements in all respects, and moreover, is the "finest lubricant" ever produced by the refinery. The criteria for judging the virtues of the "finest lubricant" are extremely vague. The whole situation is most disturbing, for nobody appears to have any very definite notion of how to analyze the difficulty.

In sheer desperation, a "freak" kind of oil is used as a last resort, and all are elated to discern a distinct alleviation of the trouble. Examination of the oil-specification test-data discloses nothing unusual except, perhaps, a failure to pass the emulsification test, a matter of scant import. Presently, under vows of secrecy, it is learned that the oil has been "com-

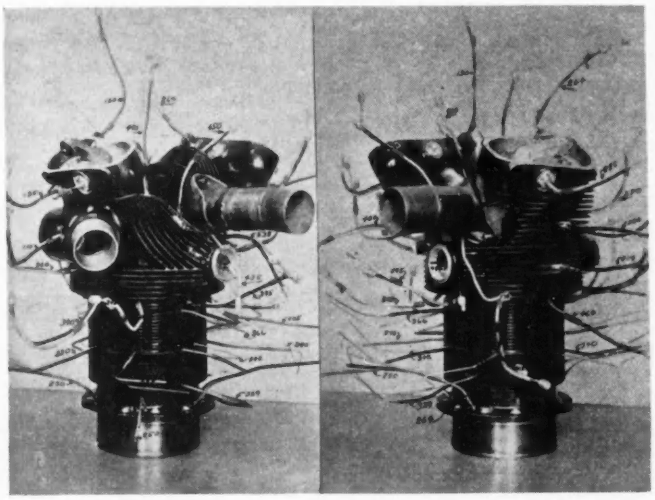


Fig. 3—A Sample Set of Readings of the Temperature Levels over a Cylinder

pounded" with some mysterious ingredient. Tests in an unprejudiced machine show that the "compounding" has added to the base oil a surprising ability to carry-on under difficult conditions, as in Fig. 5, which shows that, for given conditions of unit loading, P, and rubbing velocity, N, the coefficient of friction, μ, is a function of the viscosity, Z, as long as a fluid film separates the bearing and journal.

$$(P/N)\ \mu = fZ$$

The fact that these functions differ in marked degree for the original and "compounded" oils indicates a need for intensive investigation of this phenomenon. During the last two years we have found at least one oil which has the highly desirable "oiliness" qualities and, at the same time, exhibits excellent durability and resistance to oxidation. It is most important that other oils of this type be made generally available.

Returning to a further consideration of the data of Fig. 5, it will be seen that, if a bearing temperature of about 200 deg. fahr. is assumed as a maximum, the minimum value for Z is determined for any specific oil. For similar oils, the limiting value of μ may be quite accurately determined. From experience with numerous bearing applications, the limiting ratio P/N may be determined experimentally, and the whole formula may then be set up as an empirical relation for a limiting temperature and type of oil; that is,

$$(N/P) = (fZ/\mu) = K$$

From this empirical, but reasonable relation, assuming proper structural rigidity, adequate oil-flow and entrance conditions, we should be able to tell in advance whether a stated bearing can possibly survive and, by the same token, whether the lubricating value of an oil is satisfactory.

The fact that a high load-ability can be obtained without sacrificing all other desirable characteristics is illustrated in Fig. 6, where the temperature-viscosity relations for several oils are shown. It has been demonstrated that satisfactory starting can rarely be obtained if the temperature is such as to give a viscosity greater than 50,000 sec. In Fig. 6 it will be seen that the sample A having the prime load-ability also has a fair viscosity-slope, though it is by no means as good as oil B, the best seen up to this time. However, the performance of sample B was inferior in most respects, and it is shown only because of its extraordinary low-temperature qualities.

The immediate problem is in the combination of a compounding agent for improved load-ability in the region of the film-boundary lubrication, plus an agent for improving (reducing) the viscosity ratio or temperature slope, plus the best available base-oil, which in this country is probably represented by a solvent-treated Pennsylvania-stock, the resulting potage to have a maximum of oxidation stability in a high-output aircraft-engine.

It is suggested that progress in the study of load-ability in film-boundary conditions would be accelerated if the various methods of testing this quality could be divorced from bias due to peculiarities in the fluid-mechanism of the means provided for supplying the oil to the bearing surfaces. Use of the Kingsbury or Michell slipper-bearing construction or application of the principles involved to a cylindrical journal and a partial-bearing ring probably would eliminate many of the present discrepancies in test results and greatly facilitate the progress of a proper understanding of the problem. This matter should be handled by cooperative action from which predetermined bias has been rigidly excluded.

It will be loudly proclaimed by some that the methods discussed for improving lubricants are impractical because they involve the use of materials which may cause corrosion of the bearing surfaces. Experience has demonstrated that with use of proper materials no serious corrosion need be expected and, moreover, an etched bearing is in most cases to be preferred to a melted bearing.

The problem of piston-ring gumming and oil sludging in service becomes increasingly difficult as the power output and temperature level are increased. However, it has been amply

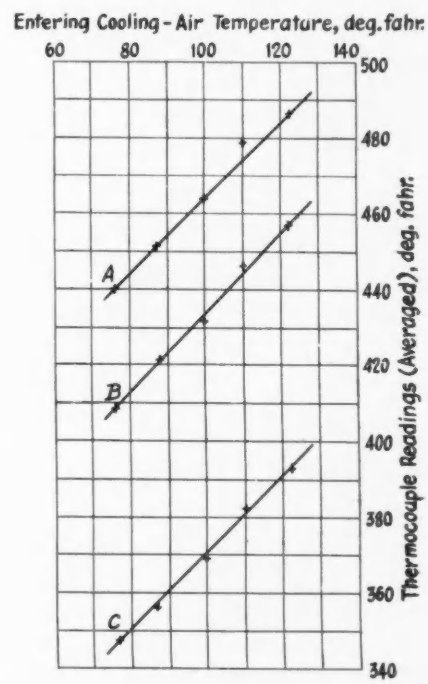


Fig. 4—Curves for a Typical Run Which Show the Relation of the Entering Cooling-Air and Cylinder Temperatures

Curve A—exhaust port (4 thermocouples), curve B—combustion chamber (6 thermocouples), and curve C—top of barrel (5 thermocouples). The conditions held constant were the carburetor-air temperature, fuel-air ratio, manifold pressure, spark advance, crankshaft speed, cooling-air velocity, and brake horsepower

Table 2—Comparison of Performance Obtained with Two Types of Spark Plugs

	Fuel Consumption, Lb. per B.Hp-Hr.	Cylinder-Head Temperature, Deg. Fahr. Maximum	Cylinder-Head Temperature, Deg. Fahr. Average	Brake Horsepower	Absolute Manifold Pressure, In. Hg.	Cooling-Air Temperature, Deg. Fahr.
Conventional Spark Plug	0.62	490	460	750	35.5	75
New Finned Spark Plug	0.56	440	400			
Conventional Spark Plug	0.48	400	380	450	26.0	75
New Finned Spark Plug	0.46	340	320			

demonstrated that satisfactory performance in this respect can be obtained without material sacrifice of other desirable characteristics. When this optimum condition is obtained, a very real benefit is realized in reduced wear and increased service between overhauls. One operator is obtaining 700 hr. of service between major overhauls without any intermediate "top" overhaul, and the results appear to be entirely acceptable.

Spark Plugs

When using currently accepted types of spark plugs in engines of high output, it is commonly expected that they will be operating in a range either closely approaching or actually in preignition and/or detonation. If this is not initially true, then the output probably will soon be increased until this limit is reached. Under these conditions, the electrode materials oxidize or burn away at a rapid rate and, because of their high operating temperature, the electrodes are frequently subject to corrosion when using highly leaded fuels. Moreover, it often happens that the lead compounds deposited on the spark-plug insulation reach their fusion temperature and, under these conditions, the electrical resistance across the spark-plug electrodes falls to a relatively low value. This apparently results in faulty ignition of the fuel-air charge and a material loss of power. The high operating temperatures attained by the electrodes, even at a low output, frequently result in intermittent continuation of ignition after the magnetos are grounded when stopping an engine, a most annoying and sometimes dangerous condition.

In an attempt to remove this present difficulty and shift the limitation on output to some other unit, at least temporarily, the variables of spark-plug design have been reassembled in a new way with high thermal conductivity as the governing consideration. A comparison of this type and that of a more conventional spark plug is shown in Fig. 7.

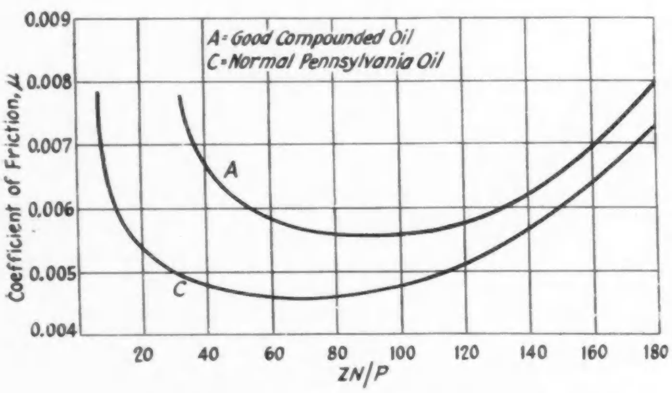


Fig. 5—Curves Showing Variation of Coefficient of Friction with Change in Ratio of Working Viscosity Z Multiplied by Rubbing Velocity N, to Unit Loading P

Insufficient service experience with this type of spark plugs prevents stating that it is thoroughly satisfactory, but no serious difficulties have yet been encountered and it has been determined that it has accomplished a definite improvement in regard to lead fouling and electrode burning. In addition, the temperature at the terminal has been reduced, which considerably eases the burden of trouble with ignition cable. Table 2 shows characteristic results obtained with conventional spark plugs and with the new type of finned plugs used in the same type of engine. It should be noted that both spark plugs have the same length of mica exposure and similar electrode-shapes.

Selection of Compression Ratio

If the engine under development is to be used for long flights, the choice of the compression ratio is worthy of much study because of its effect on fuel consumption. Assuming that a cruising power-output and speed can tentatively be established on the basis of previous experience and engine-calibration data, that the supercharger characteristics are fixed by airplane and route requirements, that the combustion-air intake-temperature limits are known, and that the characteristics of the fuel supply to be used have separately been determined, it is suggested that the compression-ratio selection should be that which will result in minimum fuel-consumption without detonation in normal-cruising operation. When this practice is followed, unusual provisions are required to cope with the imperative demands of higher power during take-off, climbing and for emergency use.

For airline engines, it is sensible to use as much fuel as may comfortably be digested by the engine for the alleviation of cooling difficulties during operation at more than normal cruising power. The matter of fuel economy during these relatively short intervals is of small importance. Even in the case where an abnormally high power-output is required for a protracted period, as when one of four engines fails completely, an increase in specific fuel consumption of about 33 per cent may be had for the same total hourly fuel consumption with a penalty of about 7 per cent in cruising velocity. In actual practice, this case probably represents a limiting condition, and it is therefore apparent that as much fuel as is useful may logically be employed for cooling at or near maximum power-output. As an alternative or supplementary method of dealing with this problem, a special grade of fuel or a temporary addition of an anti-detonating dope such as water or tetraethyl lead may be used. So many

variables are present in the general problem that a compromise solution is nearly always selected.

Fuels

The selection of a compression ratio is inseparably linked to the type of fuel to be used, and the fuel problem is perennially present. The objective is to secure a practicable fuel which will permit a larger utilization of the capacity of the engine as a mechanism without reference to thermal limitations. The American petroleum industry has recognized its opportunities and is due much credit for advances made in the last few years. It is hoped that current fuel problems may be solved in as creditable a manner.

Painstaking investigation has shown that only certain types of fuels are well suited to large high-duty aircraft-engines, and these fuels are ordinarily segregated for this use. This practice, together with the use of liberal quantities of tetraethyl lead, has permitted a major advance in engine ratings. However, experience urgently indicates the desirability of a reduction in the maximum quantity of lead being used to secure a reasonable freedom from certain operating difficulties with valves and other engine components. Field tests under actual operating conditions also show that, with present fuels, a reduction in lead content with a corresponding penalty in the resulting octane number also necessitates a reduction in the maximum safe power for cruising with present engines.

Fig. 8 shows a piston head which has been melted locally near the lower recess due to localized overheating as a result of detonation of the last portion of the charge to burn. This condition is most frequently encountered when engines are operated with fuels of low octane-number, and if the period of detonation is protracted, the melting of the piston will result in a complete failure. The valve shows a small gutter across the seating face, and is a typical case of a most persistent class of difficulties, the causes of which are not at once apparent. It is fairly clear that the effect of any warping or other detrimental influence is aggravated by the presence of tetraethyl lead in the fuel. The problem is being attacked vigorously by both mechanical and chemical means.

If advances in engines—which otherwise seem feasible—are to be realized in the near future, it appears to be a matter of necessity that the detonation qualities of the fuel be improved without increase in the lead content or any equivalent penalty. The petroleum technologists have discovered, fortunately for engine constructors, that such improvements are at least physically feasible, and it is hoped that economic obstacles can once more be ignored or surmounted in the interests of transportation progress. When used in present engines, this improved fuel should change the present thermal limitations into problems of mechanical strength and durability, for a time at least. It undoubtedly will continue to utilize at least a moderate dose of tetraethyl lead to realize its very beneficial effects on combustion stability.

Endurance Proof-Testing to Establish Rating

The accelerated endurance-test procedure followed in this country is somewhat more strenuous than that employed elsewhere and, in general, this results in a somewhat lower performance-rating than would otherwise be obtained. However, it has a definite advantage for the operator in providing a more dependable product, and it is believed that adoption of rigid standards for performance testing has amply been justified.

When it has been demonstrated that an engine will encounter no serious difficulties in the course of 50 hr. at its rated speed and power plus 100 hr. of additional testing under other operating conditions, it will generally give a good account of itself when normally running for cruising at about 70 per cent of its rated power and 90 per cent of its rated speed, provided that overhauls are at least initially not more than 300 hr. apart. This interval can frequently be increased safely on the basis of service experience. However, in some cases, service troubles develop in the field which were never experienced in the endurance-testing program, even when run for much longer periods than the requirements mentioned previously. The whole range of service operating-conditions could be duplicated in the engine-testing laboratory, but this would perpetually defer the issuance of any new development, and, as an alternative, it is considered good practice to conduct an accelerated service-test under actual operating conditions before entering extensive flight operation.

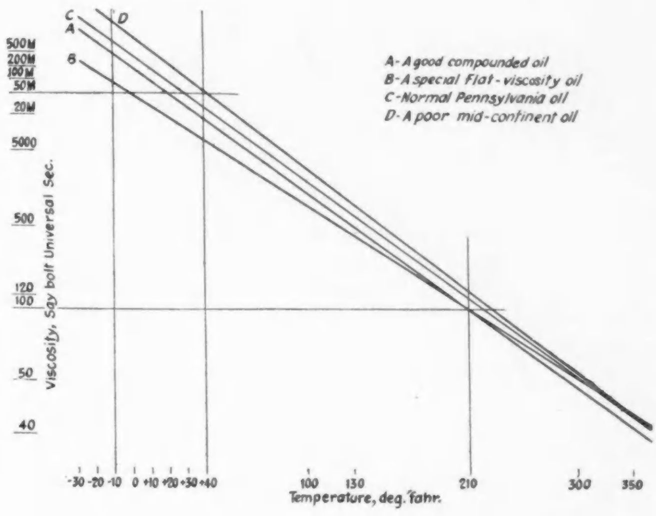


Fig. 6—Temperature-Viscosity Relations for Several Oils

It seems probable that still more stringent standards for endurance proof-testing for the cruising power-output will be adopted in the future with a superimposed requirement for proof of durability under the more strenuous take-off conditions.

Amount of Supercharging Currently Required

In airline service, an engine which has sufficient supercharging to maintain the recommended maximum power for cruising to an altitude of 10,000 or 12,000 ft. will show good performance near sea level, and may be used for take-off at about 150 per cent of the cruising power-output, which will result in a very creditable airplane performance. This type of engine is well suited to service where frequent stops are not required and a large fraction of the scheduled operation will be at about 12,000 ft. The same engine can also be used with only a minor loss in potential cruising performance at 15,000 ft., and at low altitudes its performance is inferior to that of an optimum engine for low-altitude cruising in only one important consideration, the matter of fuel consumption. This may be remedied by freeing the impeller at low levels, as shown in Fig. 9, thus giving the type a definite advantage

Fig. 7—A Conventional Spark Plug and a Finned Type Having Greatly Improved Thermal Stability

over the conventional arrangement specifically designed for a low-altitude range only.

Unless ground elevations on the airline route are a governing consideration, and so long as passenger comfort restricts most of the operations to about 12,000 ft., the type of supercharging just discussed will give optimum economy and performance. However, if the present restrictions on the cruising ceiling are raised to a higher level, the problem becomes much more complicated. Without discussing the physiological and mechanical problems involved, if it is assumed that the cruising ceiling is changed to any figure above 15,000 ft., it probably will be desirable to employ two-stage supercharging or the equivalent. Since this type of airplane for airline service is rather remote from present practices, further discussion may be postponed.

Pilot's Operating Instructions

It is observed that the operation of modern airline equipment is, at best, a rather complicated problem. When the imposing array of instruments and controls before the pilot is considered, it is apparent that all possible confusion must be eliminated from the operating instructions for the powerplant if accidental mistakes are to be avoided. The advent of the constant-speed automatic-control for the propeller will materially simplify this problem, in addition to providing several other advantages. It is believed that the matters of simplicity and precision of control of operating conditions at constant speed are much more important than the advantages of operating on any other plan except in most unusual circumstances.

Fig. 8—A Piston Head Which Has Been Melted Locally Near the Lower Recess Due to Localized Overheating as a Result of Detonation of the Last Portion of the Charge to Burn, and a Valve Showing Erosion of Its Face

With constant-speed operation the climb can be accomplished at constant manifold-pressure, giving good performance with only one simple observation to be made, so that a maximum of attention may be devoted to other matters. For level cruising at any altitude, the pilot may determine the proper manifold pressure to be used for obtaining the desired power by reference to a simple curve or table which may be prepared in advance with confidence of reasonable accuracy, and without any reference to propeller data. Manifold pressures for cruising for a typical engine are shown in the lower portion of Fig. 9, and other altitude performance data are also illustrated.

Most other items of instruction are matters of established routine with the exception of the directions for use of the mixture control. Ordinary practice becomes meaningless with automatic speed-control on the propeller, as this removes the indication of change in mixture strength formerly employed.

Control of Mixture Strength at Altitude

Flight tests made with an accurate displacement-type fuelmeter indicate that, even under ordinary conditions, it is practically impossible to obtain consistently accurate control of the mixture strength. Lacking, for the moment at least, an established type of automatic control, it is fortunate that we have been able to adapt to flight service a type of laboratory apparatus which has been used for some years in obtaining an approximation of the exhaust-gas analysis and an indirect measurement of the fuel-air mixture-ratio. It is hoped that this apparatus will soon be made available for general usage in a form suitable for airplane installations. By observation of the instrument dial, it will then be possible to observe changes in the mixture strength made with a manual control and thereby obtain the requisite accuracy. Fig. 10 illustrates the type of data obtainable, together with data on direct measurements of fuel and air quantities.

Engine Noises

The noises originating at the propeller, from the engine exhaust-manifold and from the engine mechanism, are all of such intensity that a distinct improvement in the total is most difficult. If all the mechanical noises from the engine and all of the exhaust noise were eliminated, the remaining noise from the propeller would leave the passenger with much more discomfort than is tolerable. Since elimination of mechanical and exhaust noises is extremely difficult, and almost nothing can now be accomplished with the propeller noise-problem, the airplane designers have adopted a compromise solution of the problem in cabin insulation, which is proving quite satisfactory and much cheaper and lighter than any alternative.

In spite of best efforts at insulation, the modern all-metal airplane will transmit high-frequency noises with annoying persistence. Efforts to eliminate or damp-out the vibrations at their source have not been particularly fruitful because of weight and space limitations. Persistent effort in this direction will be required for a considerable period before material improvements have been achieved without sacrifice of weight and reliability.

Induction-System Icing

The volume of trouble experienced with icing in the induction system has increased rapidly as the proportion of

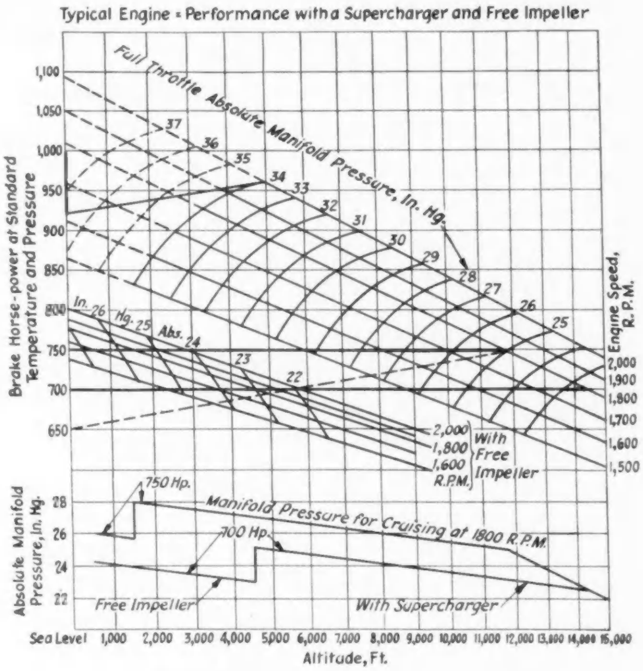


Fig. 9—Performance Obtained with Adequate Supercharging for Normal Airline Operation and Provision for Cruising with Free Impeller for Maximum Economy at Low Altitude

supercharged engines in service has become greater, and as the continuation of flight schedules through all kinds of bad weather has become common practice on airlines. After numerous and expensive experiments on various kinds of equipment for the elimination of icing, a majority of operators are using some form of air preheater with a manual control of the amount of heat supplied. It is believed that this arrangement is the lightest and best available for a general solution of the problem.

Preheating the air supply involves a severe penalty in power output, though, in the cruising condition, the throttle may be opened to compensate for the loss. Experience has shown that the fuel-air mixture-ratio being used is a most important factor in the situation, again emphasizing the need for accurate control. If the mixture is richer than need be, the vaporization of the extra fuel may readily lead to icing when a proper mixture would avoid the difficulty. This is admirably indicated by a suitable resistance thermometer bulb placed in the fuel-air stream just inside the carburetor. When this thermometer indicates a temperature above 32 deg. fahr., no serious icing difficulty will be encountered, and this temperature may safely be used as a guide in controlling the air inlet-temperature. This type of equipment and control presents obvious disadvantages, but it extends the range of adverse weather conditions under which scheduled operations may be maintained.

Importance of Careful Work

This discussion has rapidly skipped over the surface or both major and minor problems, and in many cases has failed to mention a constructive solution for the difficulties encountered. Numerous and important questions of operation and maintenance were only considered indirectly. However, it maps a few salient points, and it is hoped that these innocuous generalities may stimulate at least one fresh attack.

The importance of careful inspection and repair can scarcely be over-emphasized. In order that it may be reasonably useful and efficient in proportion to its weight, the modern aircraft engine must be stressed to a uniformly high level throughout its structure. This means that the factor of safety and/or ignorance in the design must be held to a relatively low value, and that the material inspection during fabrication and use must be nearly perfect. The use of magnetic inspection for flaws is spreading rapidly, and should be available in all overhaul stations. Even X-ray inspection of new material is justifiable in some cases.

Engines will be run in service until excessive wear, mechanical failures, or obsolescence eliminates them. Since many of the mechanical failures are traceable to fatigue of materials, improved performance in this regard is urgently needed. It is evident that if all details of the design are properly proportioned so as to balance nicely the utilization of each bit of material, the smallest fault in manufacture or inspection will probably cause a failure sometime during the useful life of the engine. For this reason, it is most essential to inspect minutely every part of an engine at regular intervals of service.

With the best of intentions and a maximum of care in design, manufacture and operation, it is almost mathematically certain that some failures will be encountered in service. The severity of the penalty which may result from these accidents or mistakes is grave indeed, and the recognition of these hazards is one of the basic causes for the tense activity, as well as for the paradoxical levity, of the personnel of the aircraft industry.

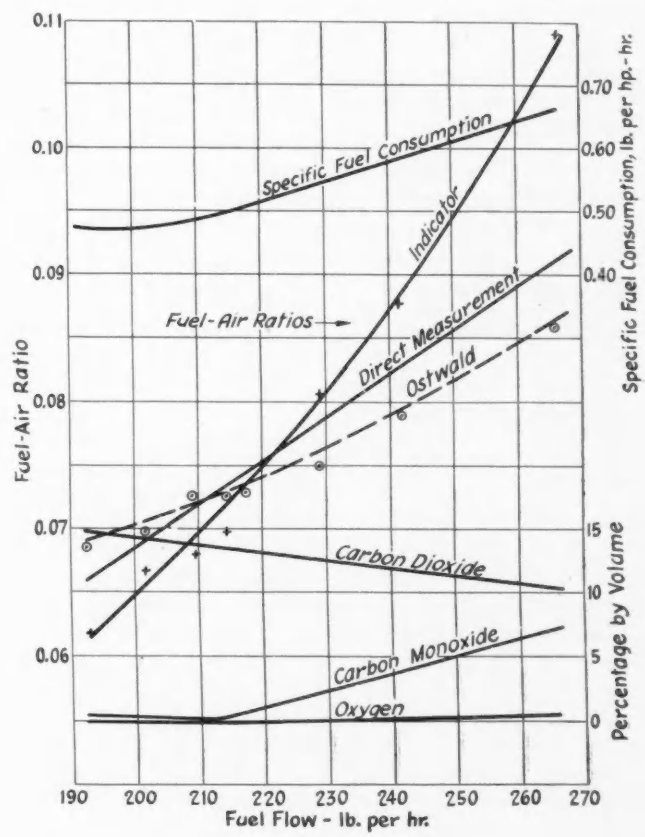


Fig. 10—Mixture-Strength Indicator-Readings Compared with Specific Fuel Consumption, Measured Fuel-Air Ratios, and Exhaust-Gas Analysis

Problems in the Development of a High-Speed Engine

By Stanwood W. Sparrow

Studebaker Corp.

THE engine considered in this paper is an eight-in-line of 3 1/16-in. bore and 4¼-in. stroke having a piston displacement of 250 cu. in.

After comparing the performances of the "FD" and the 8-250 engines, Mr. Sparrow relates in detail the changes made in the engine under consideration and states the results obtained by tests, also commenting thereon.

The subjects considered include valve timing and lift, intake pulsations, distribution, compression ratio, ignition, blowby, oil consumption, cylinder-block cracking, valves and valve seats, valve springs, pistons, crankshaft failure, connecting rods, and bearings.

Numerous data are presented in chart form, together with other pertinent illustrations of the subjects discussed.

THIS is to be a history rather than an instruction book and, like most histories, it will deal with problems of sufficient interest to be remembered rather than with those of most importance. The engine to be considered is an eight-in-line, with a bore of 3 1/16 in., a stroke of 4¼ in., and a piston displacement of 250 cu. in. It met the original requirements of performance and life without an undue amount of development work.

We criticize the old gray mare because "she ain't what she used to be" but, as the years roll by, an engine must be much better than it used to be, if it is to escape criticism. As for this engine, what has been accomplished from a performance standpoint is shown in Fig. 1. The "FD"—as it was called in its youth—had a maximum torque of 164 lb-ft. and 81 b.hp. The 8-250, as it is now known, gives 202 lb-ft. of torque and 110 b.hp. In conjunction with the increase in performance, the permissible speed for continuous operation has been increased from 3600 to 4500 r.p.m. This latter figure is based upon the ability of the engine to operate for 50 hr. at full load without shedding any vital parts.

Valve Timing and Lift.—Engine power depends upon the weight of charge taken in during the suction stroke and an orthodox method of increasing power is to increase the lift of the valve and the duration of opening. In other words, the cylinder is permitted to open its mouth wider and keep it open longer. Fig. 2 shows that little change was made in

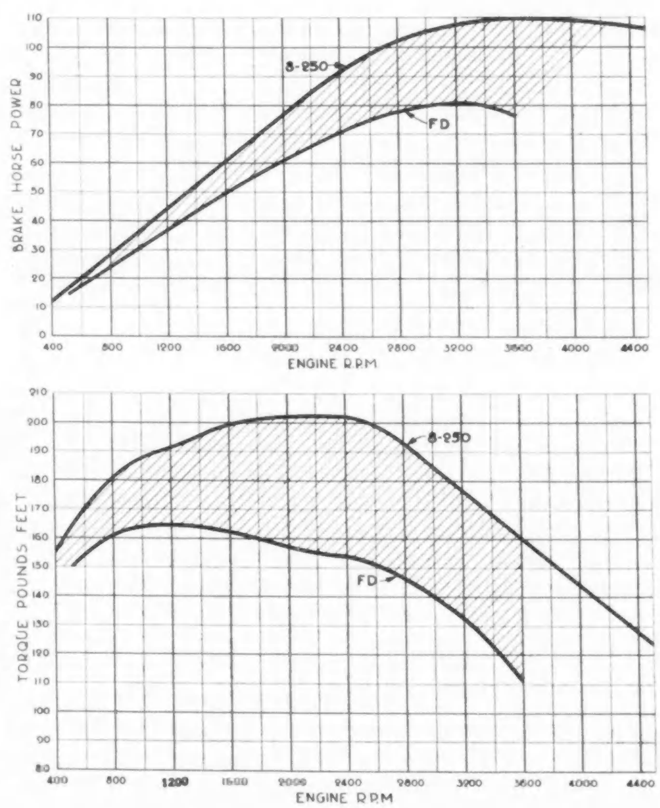


Fig. 1—The 8-250 Engine Was Originally the "FD". The Increase in Performance Was Obtained without an Increase in Displacement

[This paper was presented at the Cleveland Section Meeting held Oct. 15, 1934. Mr. Sparrow presented approximately the same paper at the Nov. 5, 1934, Meeting of the Detroit Section.]

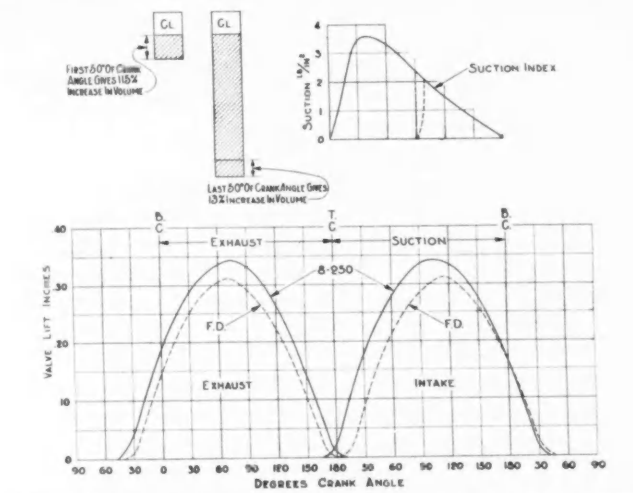


Fig. 2—Both the Valve Lift and Duration of Opening Were Increased. The Suction-Index Curve Shows One Reason for an Early Opening of the Intake Valve

the closing point of the intake valve as tests had demonstrated that a later closing would cause a loss in torque at low speeds. The importance of the early intake-opening is apparent from a consideration of the suction stroke. As the piston moves down from top center there is an increase in the volume above it and the charge expands to fill this greater volume. The pressure falls as a result of this expansion and the difference between this pressure and the pressure in the inlet manifold governs the rate of flow into the cylinder. An increase in volume of more than 100 per cent results from the first 50 deg. of rotation of the crank, whereas the last 50 deg. produces an increase of less than 15 per cent. An idea as to how this suction effect varies during the stroke can be obtained by calculating the drop in pressure for each 10 deg. of rotation, assuming the valves to be closed and the pressure to be atmospheric at the beginning of each 10-deg. interval. To be sure, this is but one of the factors governing flow, but it is a factor which becomes of increasing importance as compression ratios are increased and clearance volumes correspondingly reduced.

Duplex Manifold.—A further increase in power was obtained by replacing the single manifold by a duplex. In effect the duplex manifold consists of two independent induction systems, one of which supplies cylinders 1, 2, 7 and 8, while the other supplies 3, 4, 5 and 6. As shown in Fig. 3, with the single manifold, the suction strokes overlap by 90 deg. How this permits certain cylinders to be robbed of a full charge is brought out more clearly in Fig. 4; compression pressures, as obtained normally with a single manifold, are plotted in the lower portion. With the *same* manifold the duplex construction is approximated by closing the ports in cylinders 3, 4, 5 and 6 while measuring pressures in cylinders 1, 2, 7 and 8 and then closing the ports in the end cylinder while measuring the pressure in the central group. Cylinders 4 and 5 benefit most from the duplex construction, which indicates that these were penalized most by the single installation. A glance at the firing-order diagram reveals the reason. Only cylinders 4 and 5 are followed immediately by another cylinder on the same side of the vertical branch.

Intake Pulsations.—The foregoing sounds a bit as though the secret of increasing power consisted merely in providing the ingoing charge with a larger entrance passage so divided as to prevent crowding. Unfortunately, it is not quite so simple. Valve timing and manifold areas must be matched to take full advantage of the ramming effect which results from pulsations in the intake system. The significance of this will be apparent from Fig. 5 in which the compression pressures at various speeds are plotted for all cylinders. Up to 2800 r.p.m., compression pressures are higher with the carburetor and manifold in place than they are when the charge is taken directly into the intake ports. Hence the "ramming" effect furnished by the carburetor and manifold more than offsets the restriction which they offer.

Fig. 6 is included as an exaggerated picture of what takes place in the normal manifold. In these experiments the charge for cylinders 5 and 6 was taken through long manifolds mounted on the common port. Under conditions of minimum restriction—namely, with no manifold at all—the maximum pressure was 136 lb. per sq. in. With a 48-in. manifold, not only was the maximum increased to 152 lb. per sq. in. but in addition there was an increase in pressure as the speed was increased from 2500 to 4500 r.p.m. From the results shown in Fig. 6 it seems fairly obvious that the booster action of the intake manifold is an "organ-pipe" effect rather than a simple ramming due to the inertia of the charge in the intake pipe.

Distribution.—With the generous intake passages essential to a high power-output, gas velocities during full-load operation at slow speeds are extremely low. Hence the manifold must be provided with considerable heat to vaporize the fuel, as satisfactory distribution of liquid is a difficult problem. A curious example of distribution was furnished by an accelerated wear-test in which sand was allowed to enter the intake. Fig. 7 shows that the wear of the piston rings in cylinders 2, 4, 5 and 7 was approximately twice as great as that of the rings in the remaining four cylinders. In this engine pairs of cylinders are fed from common ports and the events are not equally spaced. For example, the suction stroke in cylinder 1 begins 180 deg. *before* the suction stroke in cylinder 2 and 540 deg. *after* the previous suction stroke in cylinder 2. In every case the greater wear occurs in the cylinder in which the suction is beginning at the time the suction stroke in the companion cylinder is being completed. Liquid, like sand, is heavier than air and distribution tests show that the cylinders which get the most liquid are those which received the most sand and showed the most wear.

Fortunately, the liquid distribution in this engine was not bad enough to cause difficulty in starting and the problem

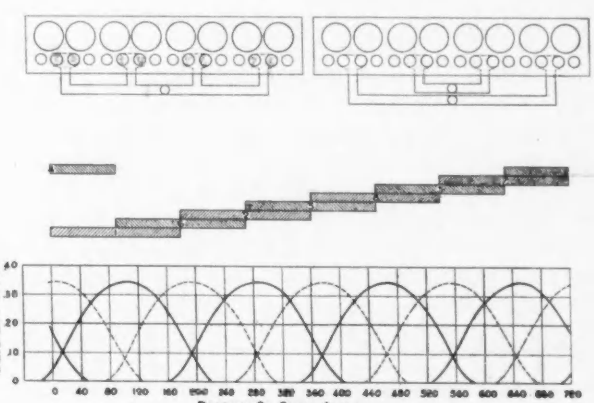


Fig. 3—With a Single Manifold the Suction Strokes Overlap by 90 Deg. and the Overlap of the Intake Valves Is Even Greater

of liquid distribution after starting is solved—or avoided—by the application of sufficient heat to convert the liquid into vapor. Excessive heating is prevented by a thermostatically controlled, unbalanced valve which shunts the exhaust gases away from the hot spot during full-load operation at medium and high speeds. With a downdraft manifold such as is now used on this engine, the problem of distribution immediately after starting is somewhat more difficult than with the up-draft construction; but the attention given to the solution of this problem is more than justified by the greater ease of starting obtainable with the downdraft. In addition, the downdraft usually permits a more favorable location of the carburetor intake and is to be preferred from the standpoint of engine accessibility.

Compression Ratio.—A portion of the increased performance of the present engine may be credited to the fact that the compression ratio has been increased from 5.1 to 6.3. Some increase in ratio was made possible by the general availability of fuels of higher antiknock value. A further increase was permitted by a change in combustion-chamber design and by the adoption of aluminum as a cylinder-head material. The change in material by itself enabled the compression ratio to be raised from 5.5 to 6.3 without any sacrifice in the factor of safety against detonation. Spark plugs with a high resistance to fouling can be used in the aluminum head without danger of preignition.

Reasons for High Engine Speeds.—The attention to be given to problems arising in connection with high engine speeds should not be interpreted as a failure to appreciate the car owner's desire for high acceleration at low speeds. On the contrary, it is a recognition of the fact that increasing the safe operating speed of an engine is one of the most effective ways of improving the low-speed performance of a car. This is illustrated in Fig. 8, which shows what can be accomplished with two engines having the same power output and differing solely in the ability of one to operate at a speed 500 r.p.m. higher than the other. In one case a top car-speed of 85 m.p.h. necessitates an axle ratio of 4 to 1 if the engine speed is not to exceed 4000 r.p.m. With a permissible engine speed of 4500 r.p.m., it becomes possible to use an axle ratio of 4.6 to 1 and, as a result, the acceleration at low speeds is increased by more than 16 per cent. This is due in part to a greater multiplication of torque and in part to the fact that at low speeds the torque of the engine increases as the speed is increased.

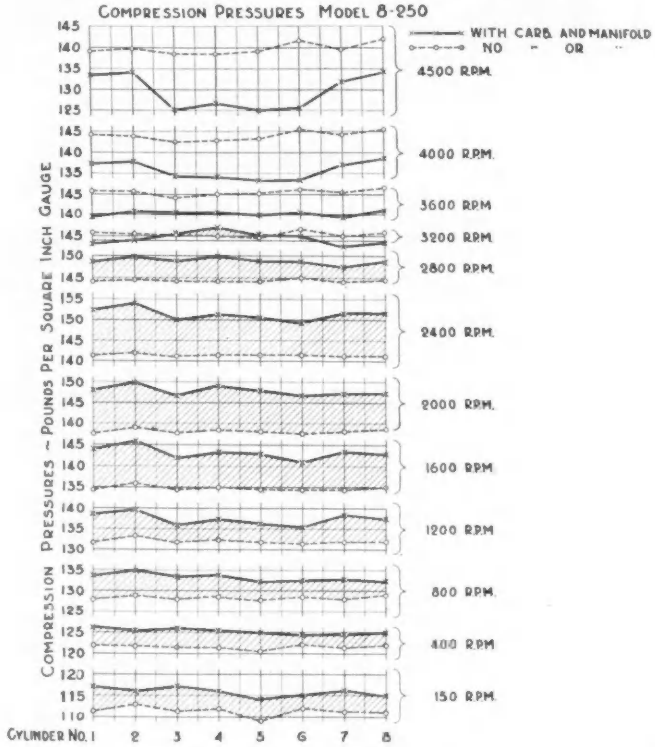
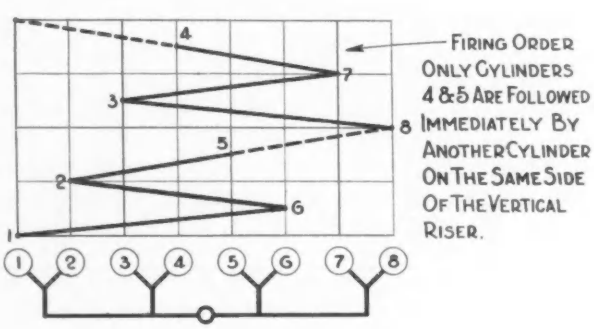


Fig. 5—At Speeds below 2800 R.P.M., Removing the Carburetor and Manifold *Decreases* the Compression Pressure

After looking at a characteristic curve of volumetric efficiency like that of Fig. 9, one naturally asks why the effort expended in improving engine reliability at high speeds might not be employed more profitably in bringing the volumetric efficiency at 400 r.p.m. up to the value now obtained at 2000 r.p.m. It is common experience to find that low-speed performance is sacrificed by changes in valve timing which increase maximum power. This has led to the belief that, in the low-speed range, volumetric efficiencies of nearly 100 per cent might be obtained if it were possible to change the timing to suit each particular speed. A little thought will show that such is not the case. Heating of the charge is a major cause of low volumetric efficiency and its influence is most pronounced at low speeds. For example, in one engine, dropping the temperature of the jacket water from 160 to 80 deg. fahr. increased the volumetric efficiency at 400 r.p.m. by 20 per cent but made less than 3-per cent difference at 3200 r.p.m. Even if a kind fairy donated an intake system with no restriction, and the charge entering the cylinder were heated only to the jacket-water temperature of 170 deg., the volumetric efficiency with an entering-air temperature of 70



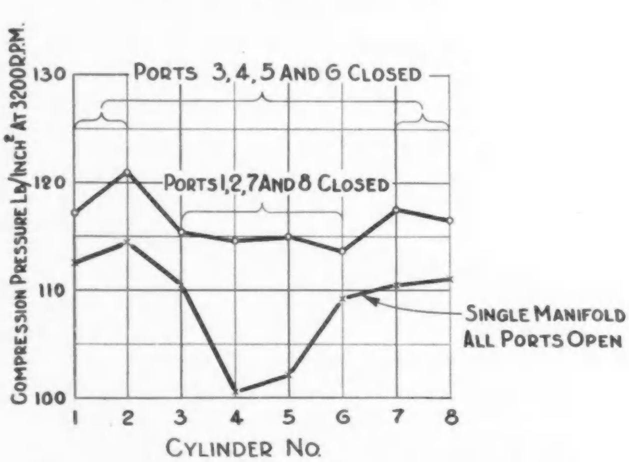


Fig. 4—An Experiment with a Single Manifold Shows Which Cylinders Benefit Most from the Duplex Construction

deg. would not exceed 84 per cent; that is $(460 + 70)/(460 + 170) = 0.84$. In fact, with most engines, the volumetric efficiencies obtained at low speeds are as high as it is reasonable to expect, and the high values which are found at certain speeds are due to pulsations in the intake system.

Ignition.—An old spark-plug advertisement describes the ignition spark as "a gas blasting blaze of withering heat that gives your motor the heart of a charging grizzly bear." For the sake of accuracy it must be admitted that, at high speeds, the spark more often resembles a "feeble firefly fluttering to the last round-up." In general, the sparking voltage becomes less as the speed is increased because of the shorter time available for saturating the coil. Several examples of this will be found in Fig. 10. The open air-gap was placed in the normal spark-plug location in order that engine conditions might be duplicated as regards vibration, length of wire, and the like. Naturally, the ignition system selected from these three, Fig. 10, was that which provided an adequate factor of safety with the least cost. For the 8-250 engine, the single-coil double-breaker system fulfilled this requirement. A satisfactory criterion of an adequate factor of safety is the ability of the engine to operate without missing or loss in power with clean spark plugs having a gap of 0.050 in., more than double the normal width.

Induced Sparks.—Firing at the wrong time because of induced sparks is a trouble which has become increasingly prevalent with the trend toward higher compression ratios. The occasional "low-speed buck" encountered in full-throttle acceleration is likely to be due to induced sparks. In a recent dynamometer test, intermittent—and very sharp—pings occurred in cylinder 7. These were traced to induced sparks caused by the high-tension lead between the coil and the distributor. To remedy this, the high-tension lead was brought in at the top of the distributor instead of at the side as in the original installation. In seeking more definite information relative to the prevention of these induced sparks, a dummy lead was placed parallel to the wire between the coil and distributor as illustrated in Fig. 11. The engine was operated normally and, although the dummy lead had no connection with the ignition system, the index plug showed continuous sparking as long as the insulated coverings of the wires were in contact. With the wire separated by 1/8 in., sparks occurred at intervals of 4 sec. and a separation of 3/8 in. eliminated the induced sparks entirely. An alternative solution consists in the use of grounded armored cables, but this has the disadvantage of reducing the voltage at the spark plugs.

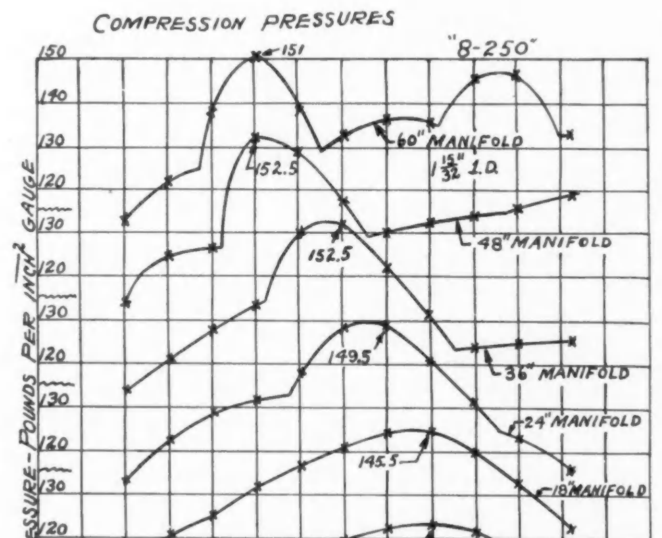


Fig. 6—The Effect of Pulsations in the Intake Pipe Is Shown by Experiments with Very Long Manifolds

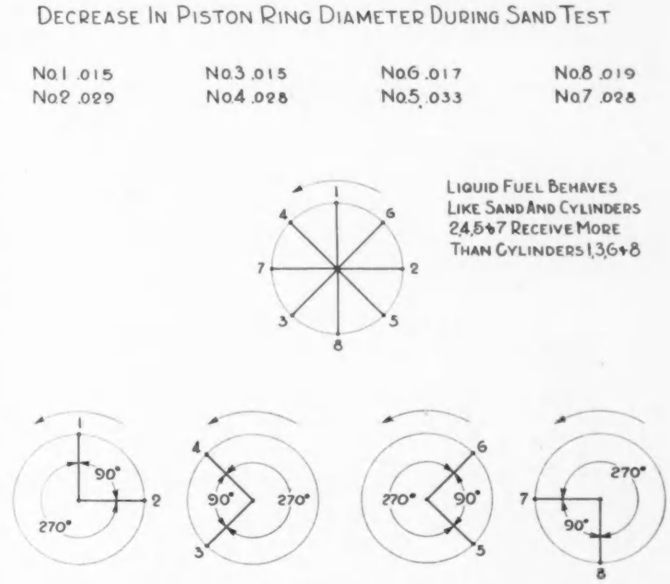


Fig. 7—An Accelerated Wear-Test Yields Information on Distribution

Blowby.—With good bores and good piston rings, the leakage of gas past the face of the ring is small—usually well below 1 cu. ft. per min. This small amount of leakage, though undesirable, ordinarily does very little harm. Under certain conditions, however, piston rings collapse and leave the cylinder walls, whereupon the blowby becomes excessive. Such excessive blowby stands high in the ranks of public enemies since it is responsible for loss in power, destruction of the oil film, rapid wear, and breakage of piston rings. A typical piston-ring casualty is shown in Fig. 12.

Ordinarily, the lower compression-ring is the first to fail when blowby is excessive. After one test made with rings of low radial pressure, the lower compression-ring on every piston was broken and in not a single instance had the top ring failed. Evidence of ring collapse is furnished by a burned-oil deposit on the face of the ring near the tip and by bright spots where the ends of the ring butt against each other. In Fig. 13, the extent of the oil deposits clearly indicates that the second ring collapsed less than the third ring and that the top ring collapsed least of all. At present it is a common

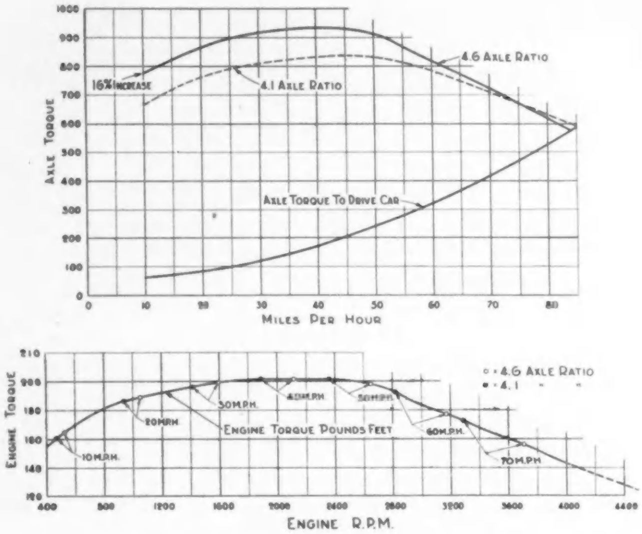


Fig. 8—Increasing the Engine Speed from 4000 to 4500 R.P.M. Makes Possible an Increase of 16 Per Cent in Axle Torque at 10 M.P.H.

practice to shape piston rings to give a high radial pressure at the tips, and this has been effective in reducing blowby.

The statement that the lower compression-ring suffers most from blowby is based upon tests in which new rings are installed and the engine is then operated continuously under conditions of severe blowby. In normal operation it is the top ring which wears the most and which is most likely to lose tension because of high temperatures. Hence, when an engine which has been in service for a long time is operated under conditions of maximum blowby, it is likely to be the top ring which fails. In such a case the failure is not due to the fact that the force tending to collapse the ring is high, but rather because the ring can offer but little resistance to this force.

Blowby curves for two engines of the same type are shown in Fig. 14. The similarity of these curves indicates that blowby is not primarily a question of smoothness of surface or nicety of fit. Fig. 15 furnishes rather convincing evidence that blowby is a maximum when there is a definite relation between the gas pressure and the inertia force. In this test blowby was measured with various throttle openings at three different speeds. Results are plotted against indicated mean effective pressure, which varies almost directly with gas pressure. At 3600 r.p.m. the blowby is a maximum when the indicated mean effective pressure is 85 lb. per sq. in. Since the inertia force varies as the square of the speed, it is possible to calculate for any other speed the indicated mean effective pressure at which the relationship between the indicated mean effective pressure and inertia would be the same as that which existed when the blowby at 3200 r.p.m. was a maximum. Fig. 15 shows that the calculated values are close to the points of maximum blowby.

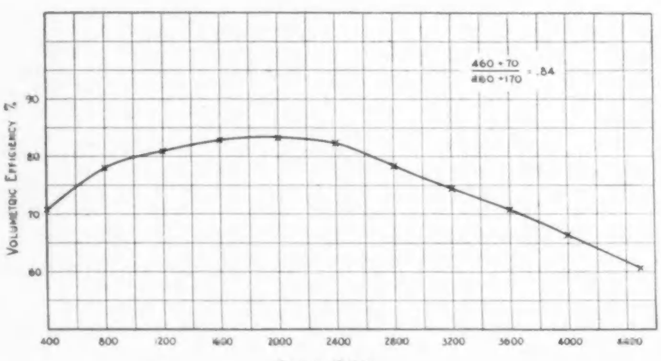


Fig. 9—A Typical Curve of Volumetric Efficiency

Fig. 16 shows that a spring ring under the top compression-ring reduced the blowby from 7 cu. ft. per min. to slightly over 1 cu. ft. per min. This might be due to the ability of the inner ring to keep the top ring on the wall or to a reduction of the rocking of the piston. The latter effect was investigated by replacing the top compression-ring with rings having flats filed on the surface so as to make them worthless as a seal. Even with these rings, the inner rings, by preventing the rocking of the pistons, reduced the blowby at 4200 r.p.m. from 6 cu. ft. per min. to less than 1 cu. ft. per min. At 4500 r.p.m. the inner ring did not have sufficient

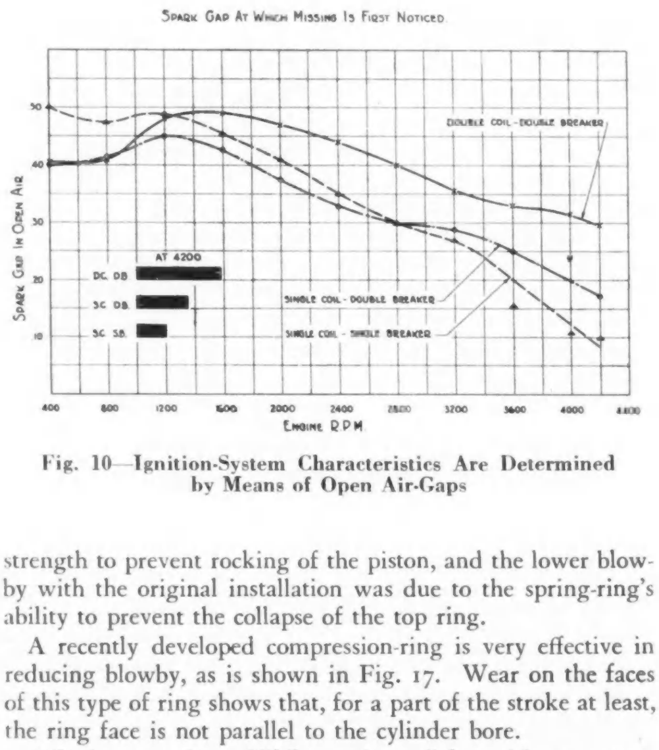


Fig. 10—Ignition-System Characteristics Are Determined by Means of Open Air-Gaps

strength to prevent rocking of the piston, and the lower blowby with the original installation was due to the spring-ring's ability to prevent the collapse of the top ring.

A recently developed compression-ring is very effective in reducing blowby, as is shown in Fig. 17. Wear on the faces of this type of ring shows that, for a part of the stroke at least, the ring face is not parallel to the cylinder bore.

Oil Consumption.—While engines differ with respect to their greed for oil, it is not uncommon to find the oil consumption increasing as the square of the speed. Hence, doubling the speed is likely to cause a 300-per cent increase in oil consumption. This is not surprising, as the influence of several factors which affect oil consumption increases with the speed. In the first place, more oil is thrown on the cylinder walls at high speeds. Then too, the "surf-board effect," or the tendency of the oil-control ring to ride over the film, is dependent upon speed. Finally, the amount of oil actually burned on the cylinder walls depends upon combustion-chamber temperatures and hence upon the amount of charge burned in the cylinder in unit time. The widespread use of oil-control rings with high unit-pressures implies a recognition of the tendency of the ring to ride over the film at high speeds. That there is a loss due to the burning of the oil film is less generally understood. With the engine under

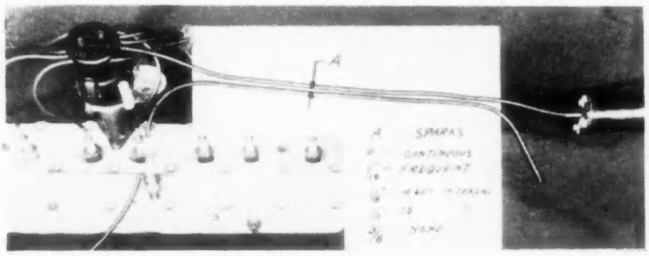


Fig. 11—Induced Sparks Can Be Prevented by Proper Spacing of Ignition Wires

discussion there was a marked reduction in oil consumption when operating at part throttle, and in a test in which the engine was motored at 4500 r.p.m. for 50 hr. with closed throttle the oil consumption was less than half as great as when it was operated at full load for the same length of time.

At the time the 8-250 engine went into production the oil consumption was not satisfactory. Baffles in the valve compartment gave considerable improvement at low speeds and an inner ring used in conjunction with the oil ring helped the situation at high speeds. Nevertheless, the oil economy frequently fell short of the demands of a public which expects at least 500 miles per gal. at any speed and better than 1000 miles per gal. at speeds below 50 m.p.h. Relief came from an unexpected source when it was discovered that oil mileages could be doubled by the removal of the top compression-ring. There is room for argument as to why this change was effective. It can be stated positively, however, that the improvement was not due to an increase in blowby as was first supposed. It has been demonstrated quite convincingly also that, with the top ring removed, the piston-land above what then becomes the top ring can be operated safely with very little radial clearance and that oil economy suffers if this clearance is increased. Presumably then, the improvement in oil economy results from a reduction in the amount of cocking of the piston in the bore or in a reduction in the deflection of the piston at the ring belt.

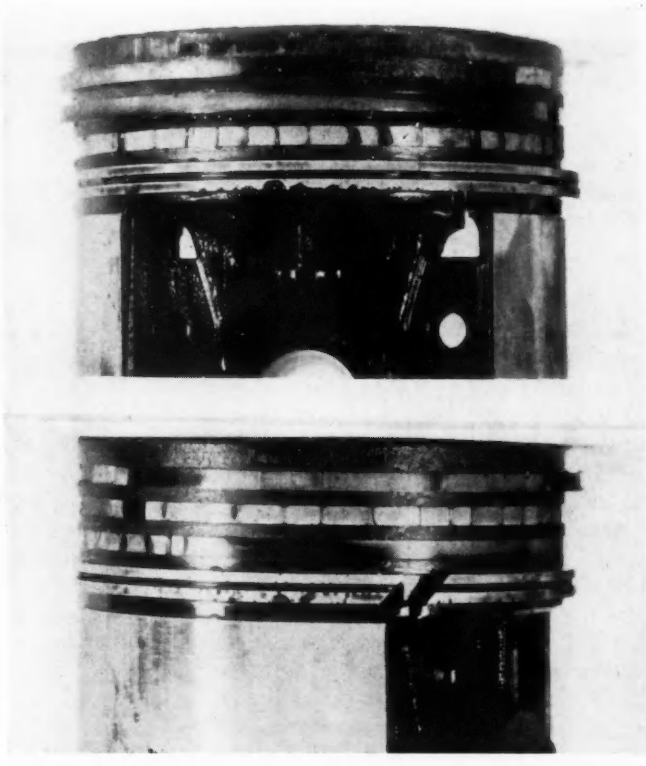


Fig. 12—Piston Rings Break Because of Excessive Blowby

Before leaving the subject of oil consumption, attention is directed to Fig. 18. To assist in visualizing the quantity of oil involved the consumption has been plotted in terms of "oil consumed per 1000 revolutions." At 4500 r.p.m., the oil consumed in a single revolution is equivalent to the volume of a disc 7/16 in. in diameter and 0.001 in. thick. This does not seem excessive when it is realized that the swept surface per revolution is equivalent to the area of a circle 29 in. in diameter.

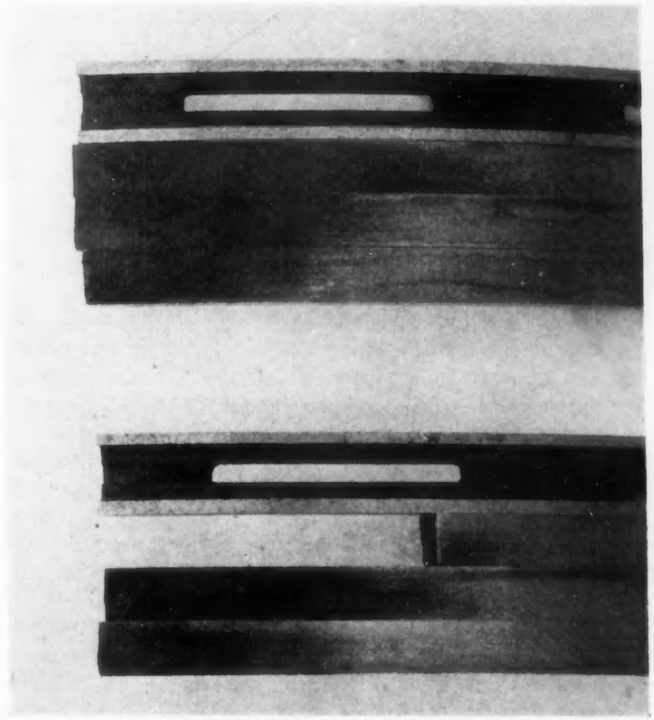


Fig. 13—In a Blowby Test the Bottom Compression-Ring Collapsed the Most and the Top Ring the Least

Cylinder-Block Cracking.—With engines of high output there is considerable danger of cracks between the cylinder bore and the valve ports. Much of the mystery surrounding the cause of such cracks vanished when it was demonstrated that these cracks could be produced by a few minutes of preignition in engines which would operate indefinitely at full throttle with no sign of failure. This pointed to high temperatures as the cause of cracking, as it is well known that the temperatures during preignition may be more than 1000 deg. higher than under normal operation.

In order to judge the ability of any particular grade of iron to prevent cracking, it was necessary to be able to produce cracking at will in production cylinder-blocks. This could be done by installing a "hot" spark-plug in one cylinder of the engine and then operating the engine at full load at a speed of 3000 to 3500 r.p.m. The engine was operated for 10-min. periods after the drop in power indicated that the hot plug was preigniting. Fig. 19 shows a spark plug after such a test and gives ample proof of the high temperatures

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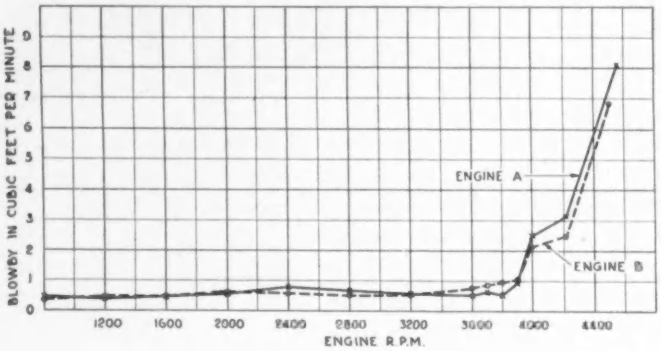

Fig. 14—Note the Similarity in the Blowby Characteristics of Two Engines of the Same Design

prevailing during preignition. Occasionally, several 10-min. periods were necessary to produce cracking; but usually, one period was sufficient.

Fig. 20 shows the location of cracks obtained in a series of tests with different types of iron. It will be noted that the cracks occur at either the intake or exhaust port and may start at the bore or at the port. In one case there are three parallel cracks which are separated by less than 1/16 in. but do not meet. One starts at the bore, one at the port, and between these there is one which does not extend either to the bore or to the port. This group supports the belief that the cracks are surface failures and are not the result of any initial strain in the casting. Cracks are produced by high temperatures in a small area completely surrounded by metal at a much lower temperature. Further proof of this high-temperature area was obtained by installing an aluminum plate between the cylinder head and block. This is shown in Fig. 21, and it will be seen that the aluminum has melted in the area where the cracks ordinarily appear although a short distance away the metal was cool enough to permit the formation of carbon. It is reasonable to conclude that the metal in the high-temperature area takes a permanent set when expansion is prevented by the relatively cool metal which surrounds it. The crack is a failure in tension and takes place when the metal cools.

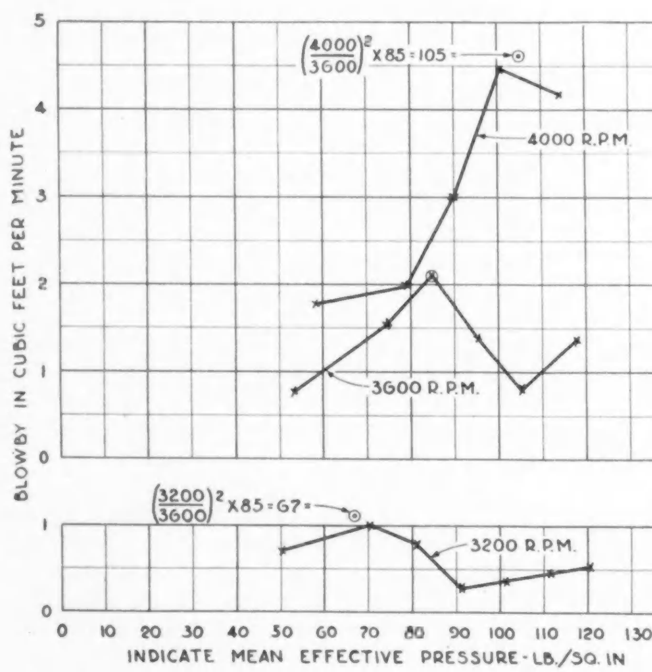

Fig. 15—Blowby Is a Maximum When There Is a Definite Relation between the Gas Pressure and the Inertia Force

An illustration of this type of cracking appears in Fig. 22. A piston was placed in water and the center of the head was heated with a torch. The head cracked as the piston cooled. Various methods of cooling and numerous types of cylinder block iron were tested and, while it is unreasonable to believe that these did not affect resistance to cracking, nevertheless it was not possible to prevent the cracking of a block when subjected to repeated preignition tests. Fortunately, however, it is extremely difficult to produce preignition when an aluminum cylinder-head is used.

Valves and Valve Seats.—Steels are available which are capable of withstanding the high temperatures to which ex-

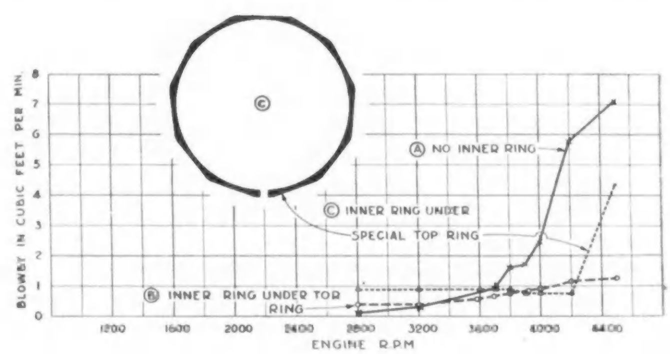

Fig. 16—Excessive Blowby Can Be Prevented by Restricting the Rocking of the Piston or by Holding the Rings on the Walls in Spite of the Rocking of the Piston

haust valves are subjected even when the tappet clearance is inadequate and there is no opportunity for heat transfer between the valve and its seat. When a valve does burn it usually is due to a slight surface crack or to some other imperfection in manufacture. Grinding the valves under their heads to facilitate the detection of such flaws has proved to be a worthwhile protection against burned valves. The pounding down of valve seats is also the result of high temperatures and with the "FD" it frequently was necessary to adjust the tappet clearance during any 50-hr. run at speeds above 3000 r.p.m. This trouble disappeared almost entirely when the valve-stem diameter was increased from 5/16 to 11/32 in. and care was taken to obtain straight holes in the valve guides. If anyone questions the importance of the valve stem as a medium for heat transfer, a test with valve stems undercut for a short distance will prove convincing. Such valves will burn under conditions which are by no means severe.

Except in rare cases where an inferior grade of fuel is used, valve sticking is confined to the exhaust valves. The sticking is due to a black enamel-like deposit which comes from the oil and is produced over a rather narrow range of temperatures. Such deposits are usually found under the heads of intake valves—where they do no particular harm—and on the stems of exhaust valves where they are likely to prevent the valve from closing. As yet no satisfactory way to prevent the formation of such deposits has been found, but the sticking of the valves can be prevented by providing sufficient valve-spring tension to shear off the deposit as it forms. In the event the tension necessary to prevent valve clatter is not

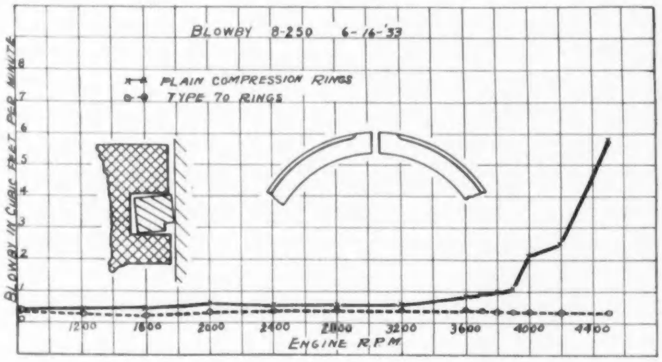

Fig. 17—A Special Design of Compression Ring Prevents Excessive Blowby

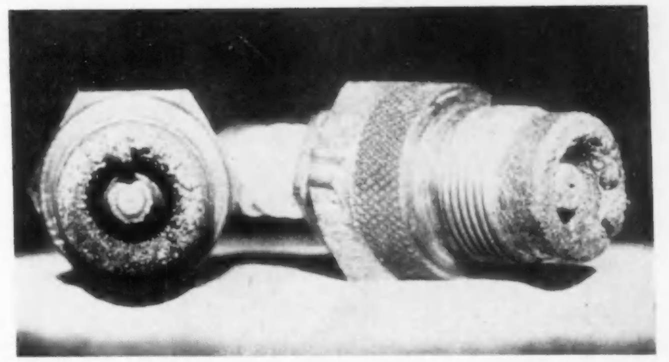

Fig. 19—Preignition Produces Abnormally High Temperatures

sufficient for this purpose, the same results can be obtained by slotting the guides as shown in Fig. 23, thus increasing the unit pressure at the shearing edge.

In considering the question of carbon deposits, Figs. 24 and 25 have been included merely as curiosities. The lavish accumulation of hard carbon on the exhaust valves and in the spark plugs resulted from a freak 50-hr. test at 4500 r.p.m. in which the engine was motored with closed throttle, with the ignition turned off, and with no fuel entering the cylinder. The deposit in the spark plugs is probably due to the low velocity at that point, as the dummy spark-plugs are free from carbon.

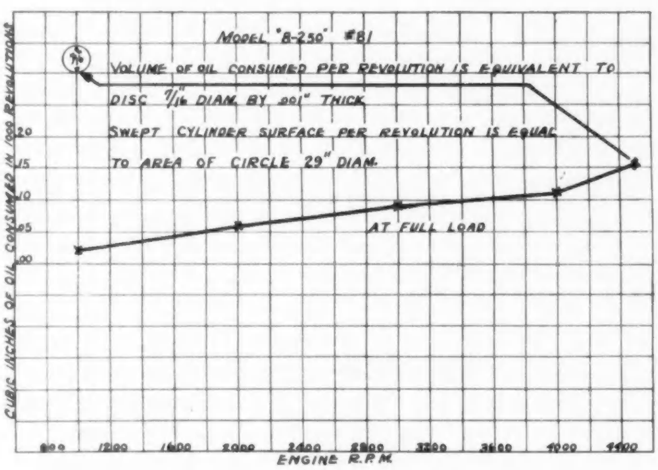

Fig. 18—Oil Consumption at Full Load

Valve Springs.—Although considerable trouble was experienced in finding a valve spring which was satisfactory for the original engine, the only changes since that time have been confined to an increase in tension to prevent valve clatter at the higher engine speeds and the adoption of valve-spring dampers to provide an added factor of safety against surge and breakage.

Pistons.—A piston may be defined as a hunk of metal essential to the operation of an internal-combustion engine and created for the express purpose of preventing engineers from becoming conceited. It accomplishes its purpose by slapping or scoring whenever the piston problem appears to be solved. Although tin-plated cast-iron pistons have been used in a companion engine of shorter stroke, aluminum pistons have always been used in this engine to prevent excessive bearing loads. Types of pistons have included the narrow strut, the wide strut, and the oval ground T-slot construction and, in general, any one of these three types may be fitted to a clearance small enough to prevent slap and still operate at full load without scoring. When a piston does score it is usually because of the heat generated when a small portion of the surface breaks through the oil film, and it is not uncommon to find no evidence whatever of scoring on the opposite thrust face.

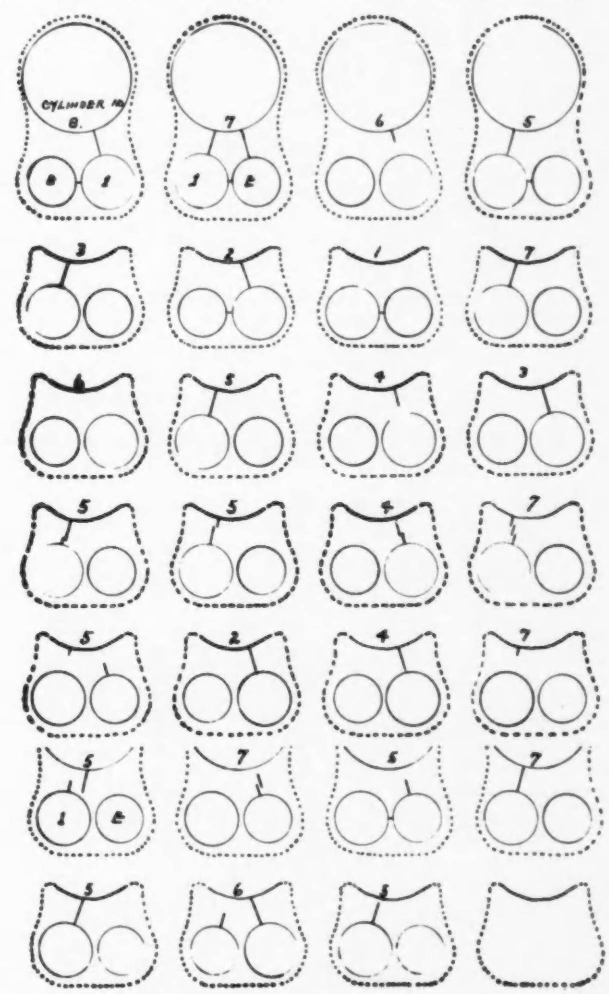

Fig. 20—Cylinder-Block Cracks May Start at Either Valve-Port or at the Bore

From the standpoint of the piston, the efforts to prevent scoring may seem woefully inadequate. In the interest of oil economy, oil-control rings of high unit-pressure are provided to scrape the oil from the cylinder walls as effectively as possible, and the film which remains is subjected to almost continuous flame. Under such conditions the piston is allowed 1 sec. in which to complete 75 round trips between top

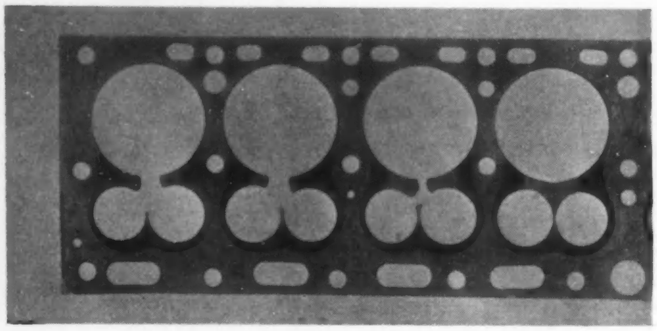

Fig. 21—An Aluminum Plate between the Cylinder Head and Block Shows the Location of High-Temperature Areas

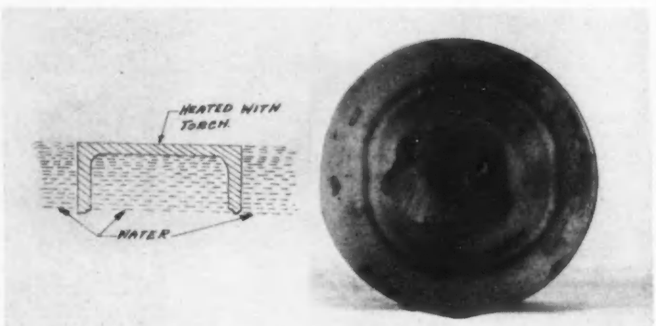

Fig. 22—The Conditions Which Cause Cylinder Blocks To Crack Are Illustrated by Heating a Piston Entirely Surrounded by Water

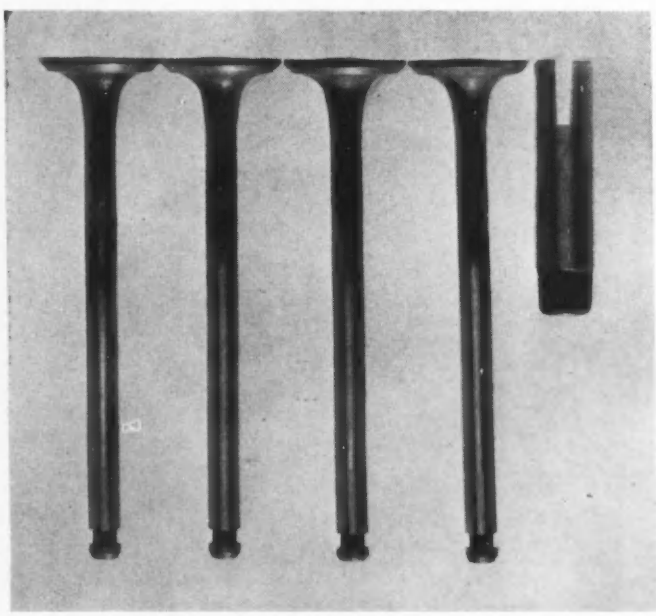

Fig. 23—A Slotted Valve-Guide Permits the Deposit on the Valve Stem To Be Sheared Off and Prevents Sticking

Fig. 24—Carbon Deposited on Exhaust Valves During a Motoring Test

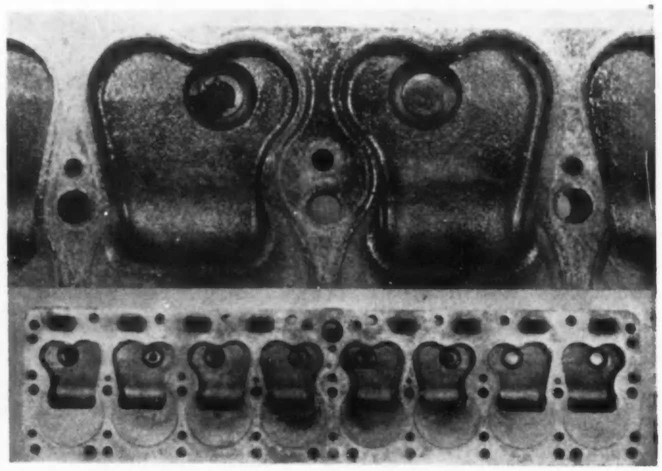

Fig. 25—Carbon Deposited in Spark Plugs During a Motoring Test

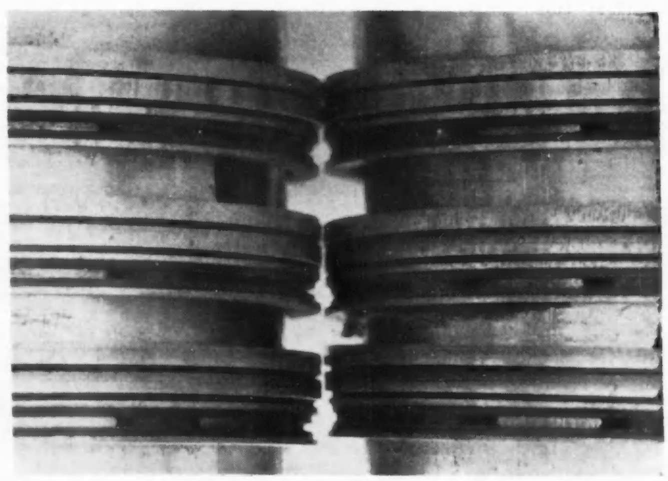

Fig. 26—Piston Rings after Three Successive 7-Hr. Tests in New Cylinder-Bores

Tool marks are still visible on the bottom sets of rings, showing that the roughness of the bores has been reduced by the two previous 7-hr. tests

and bottom center and is expected to remain cool. Strangely enough, it usually succeeds.

In reality, the requirements for good oil-economy are not inconsistent with those for good lubrication. A thin oil-film usually means a cool oil-film with the minimum amount of oil burned to carbon. To prevent metal-to-metal contact, however, smooth cylinder bores are essential. Fig. 26 shows three sets of rings, each of which was operated for 7 hr. in bores which, until recently, were considered entirely commercial. The upper groups of rings were used during the first 7 hr. The tool marks are entirely worn away and, in addition, there are numerous brown spots which indicate the passage of hot gases past the face of the rings. Rings used in the third test are shown at the bottom. All of these show the original tool marks. With properly finished cylinder bores the initial run should cause at least as little wear as occurred with the second set of rings.

Crankshaft Failures.—A crankshaft failure such as is illustrated in Fig. 27 is almost invariably the result of torsional vibration of the crank due to an inadequate vibration-damper. In the absence of damping, the crankshaft used in this engine shows torsional periods at the speeds indicated in Fig. 28. The most violent period is found at 3100 r.p.m., where each oscillation of the crank coincides with an explosion or, rather, with a torque peak. The period at 2250 r.p.m. is not particularly severe, but with certain types of vibration dampers it has been more troublesome than the periods at 3100 and 1550 r.p.m.

Two types of vibration dampers which have been used on this engine are shown in Fig. 29. The damper originally used was similar to that shown at the left of the figure except that it lacked the automatic adjustment for speed which is provided by the balls. In order to keep the magnitude of the crank oscillations at a minimum, the pressure on the friction discs should be as high as possible without preventing the

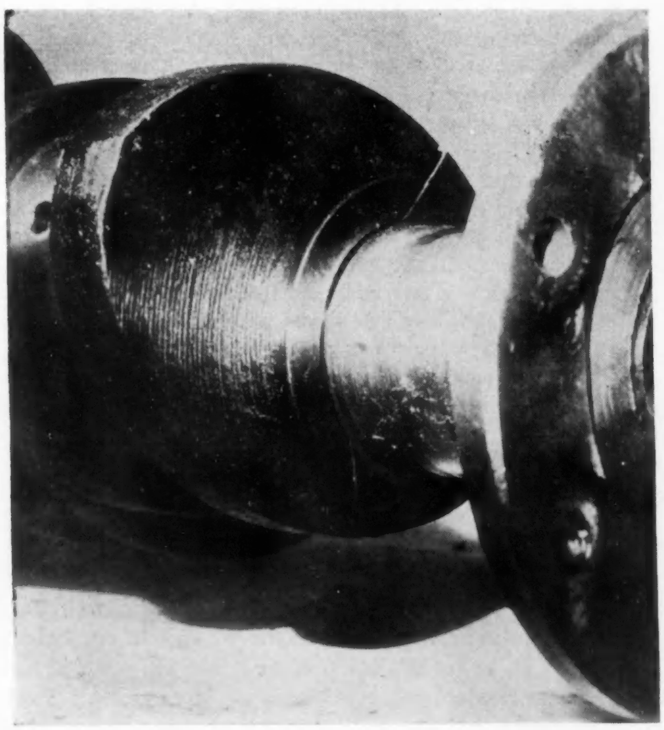

Fig. 27—Torsional Vibration Due To Inadequate Damping Causes Crankshaft Failure

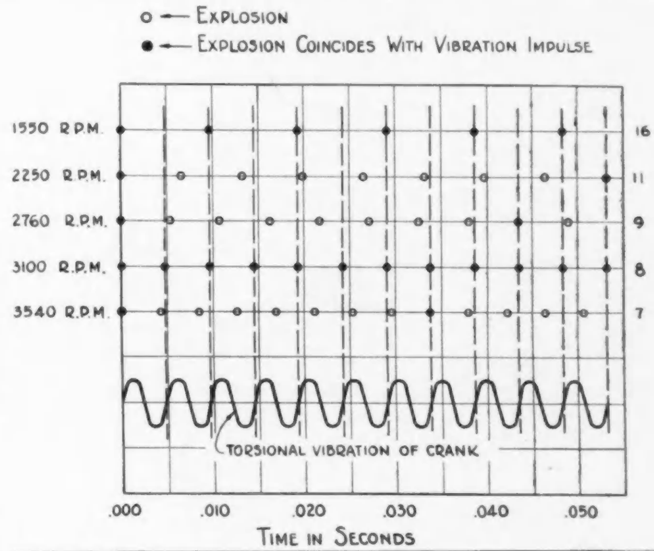

Fig. 28—In the Absence of a Vibration Damper, Torsional Periods Are Observed at Five Speeds

damper from slipping. With a setting high enough to give the best results at 3100 r.p.m., however, the damper would not slip sufficiently to provide satisfactory damping for the periods found at the lower speeds. In the damper shown in Fig. 29, the initial setting was low and, as the speed increased, centrifugal force acting on the balls increased the load on the discs. This damper gave satisfactory control except in a few cases where gum formed on the surface of the friction discs and caused sticking. Trouble from sticking has not been encountered with the oscillating type of damper shown at the right in Fig. 29. In this case, motion of the damper flywheel is resisted by rubber bushings and the resistance increases with the deflection. The initial setting is determined by the amount the rubber is pressed into the tapered hole, and can be varied by means of shims. Any vibration which might originate in the damper itself is taken care of by the friction disc between the damper flywheel and the face of the fan pulley. At very high speeds the damper flywheel has shown some tendency to run out, and this has been corrected in the present design by means of a centering collar of fiber.

The torsion records in Fig. 30 have been included primarily to show that the effect of a stuck damper is to lower the fundamental period from 3100 to 2500 r.p.m. This also introduces a period at 4000 r.p.m. with five oscillations in two revolutions. The records at the top of Fig. 30 show that the damper gives adequate control.

Connecting Rods.—Fatigue failures due to a sideways deflection have been responsible for the few cases in which a connecting rod has broken. Fig. 31 shows a rod bent in a testing machine and indicates the areas of maximum stress. To increase the factor of safety, the 8-250-engine rods have been "fattened" at the big end and, to reduce stress concentration, a cylindrical instead of a flat surface is employed to keep the bolt from turning. In addition, the steel has been changed to give added fatigue resistance.

Bearings.—Bearings will be treated briefly, as they were discussed at length in my previous paper presented at the 1934 Semi-Annual meeting of the Society[1]. In the first experimental engines, main bearings 3, 5 and 7 received an

[1] See S.A.E. Journal, July, 1934, p. 229.

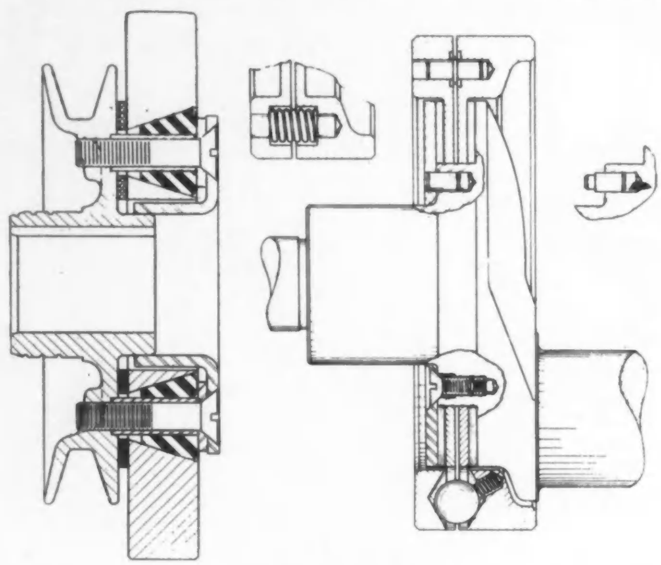

Fig. 29—Dampers of Rotating and Oscillating Types

undue amount of punishment in an endurance test at 3500 r.p.m. Before going into production, however, the shaft was counterweighted and satisfactory bearing life was obtained at what was then the top speed of the car.

Later, thin-back bearings came into the picture and were of interest primarily because of low cost. The first tests were very disappointing. A test was then made with bearings which were made from production bearings by turning down the outer shell. These behaved the same as the thick-back production-bearings, which showed that the thickness of the shell did not have a major influence on bearing life. Subsequently, changes were made in the thickness and analysis of the babbitt and the performance was in every respect as good as with the bearings with thick shells. When engine speeds began to be carried above 4200 r.p.m., the bearings again became a source of worry and the possibilities of copper-lead as a bearing material were investigated. In the first tests with this material, wear on the crank was excessive and this was corrected by an increase in oil pressure.

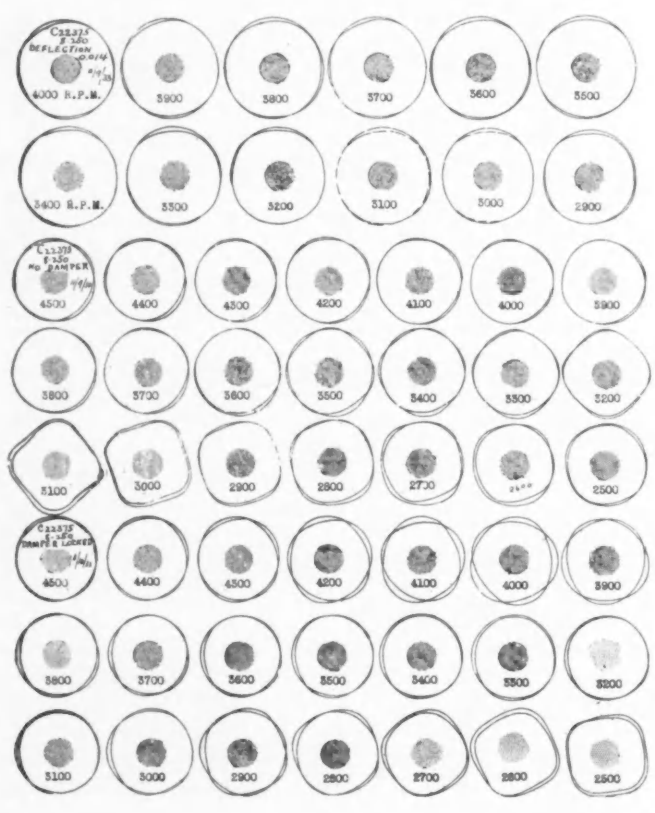

Fig. 30—Torsion Records Show the Effect of a Stuck Damper and of a Properly Adjusted Damper

Connecting-rod bearings have been of the three types shown in Fig. 32. The first rods had babbitt flanges on the sides and cracks in the bearing surface proper would frequently extend to these flanges and cause large pieces to fall out. This would permit the cracks in the remainder to spread and bearing failure would soon follow. Considerable im-

Fig. 31—Connecting-Rod Failures Are Due To Lateral Deflections

provement resulted from the elimination of the babbitt flanges and a further improvement from the adoption of the copper-lead liners. There is plenty of opportunity for further improvement in engine bearings but, nevertheless, the factor of safety against bearing failure is as high at 4500 r.p.m as it was in the original "FD" at 3500 r.p.m. and a 50-hr. full-load run at 4500 r.p.m. leaves the bearings in good condition.

In connection with the bearing tests, a considerable amount of information on lubrication was obtained with a test set-up which made it possible to measure the amount of oil supplied to the crankpins. These tests showed that, under certain conditions, at high engine speeds, the amount of oil entering the main journals was not adequate for the lubrication of the rods. Methods which proved effective in increasing the amount of oil supplied to the crankpin included an increase in the length, width, or depth of the main-bearing groove, or an increase in the oil pressure. In view of the importance of oil pressure, Fig. 33 is of interest as showing the extent to which oil pressure may be affected by a change in the clearance of the main and connecting-rod bearings. At an engine speed of 4500 r.p.m., the oil pump delivers in excess of 10 gal. per min. with a discharge pressure of 40 lb. per sq. in. At 3200 r.p.m., an increase of 0.003 in. in the diametral clearance of the main bearings dropped the pressure from 68 to 28 lb. per sq. in. and a similar increase in the clearance of the rod bearings produced approximately the same pressure drop. The effect of this change upon the main-bearing leakage and upon the actual flow to the connecting-rod bearings is shown in Fig. 34. Attention is directed to the curve showing the

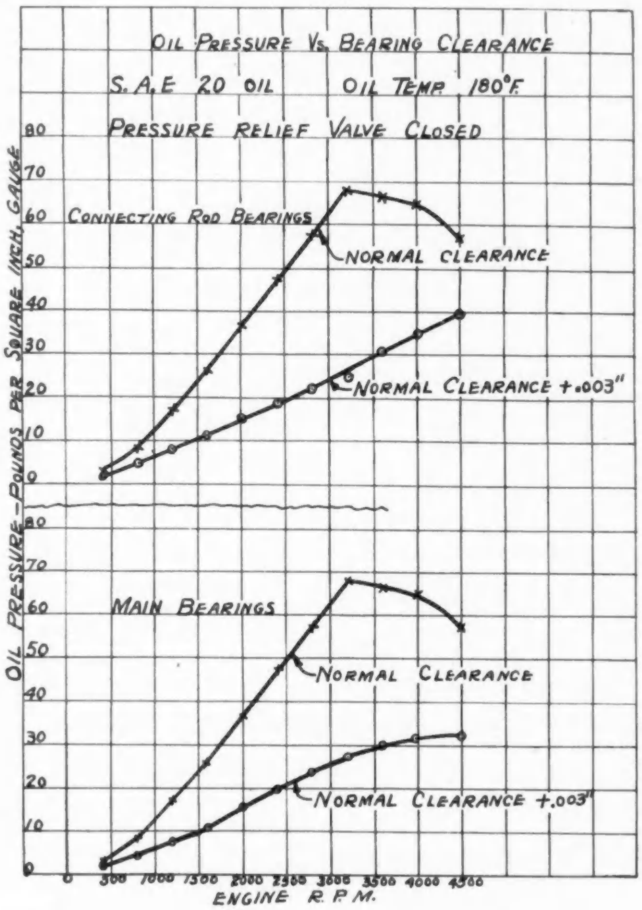

Fig. 33—An Example of the Relation between Oil Pressure and Bearing Clearance

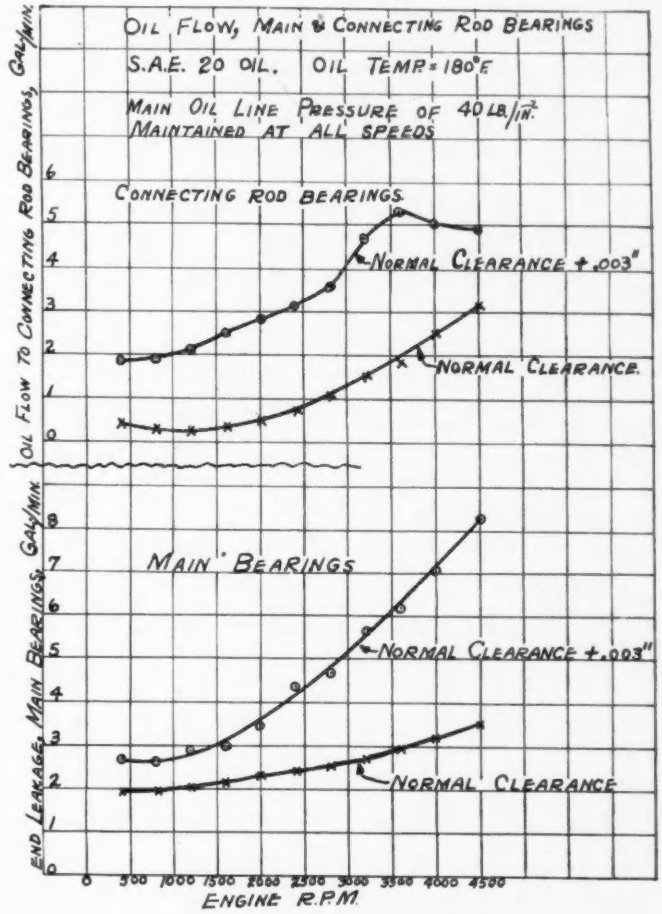

Fig. 34—An Example of the Relation between Oil Flow and Bearing Clearance

oil flow with excessive clearance in the rod bearings. The break in the curve at 3600 r.p.m. is another illustration of oil flow being limited by inability to get more oil into the crankshaft.

Any report on an engine which is still in production must be classified as "unfinished business." If, however, there is truth in the tradition that the most serious difficulties are encountered during the first 100 years, then another 90 years should see most of these problems nearing a final solution.

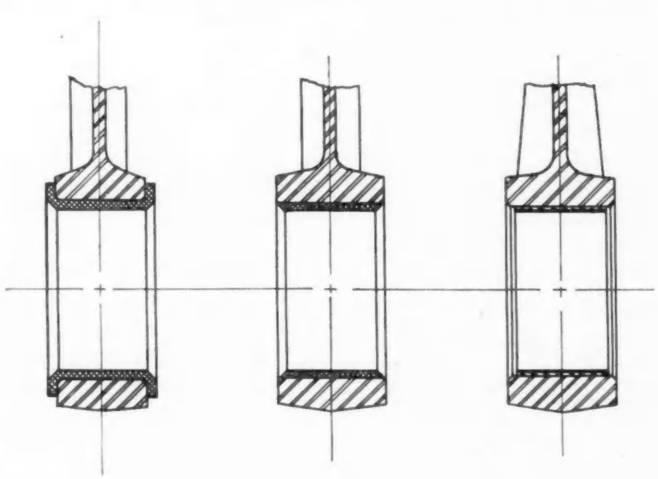

Fig. 32—Three Types of Connecting-Rod Bearings Have Been Used in This Engine

Modern Resistance Welding

THE automobile industry deserves more credit than any other branch of industry for the rapid development electric resistance welding has made in the last ten years. In the beginning of this period we admit frankly that the resistance welding industry could not be considered an established fact. Butt, flash seam and spot welding machines were built for smaller production.

To suit high production requirements of the automobile industry, not only these above mentioned methods were very highly improved but many new welding methods were added to those we already had. For instance, the spot welding method brought us the projection and cycle welding processes. From the butt welding method we developed the flash welding process. In addition to that new current controlling devices were introduced which enabled us to control the welding time automatically and take the control away from the welding machine operator.

Excerpts from a 1935 Annual Meeting paper by P. W. Fassler, president, P. W. Fassler & Co., and consulting welding engineer, Detroit.

The Performance of Engines at Low Operating Temperatures

By A. J. Blackwood
Standard Oil Development Co.

STARTING, oil pumping, sludging and wear are the subjects considered specifically in connection with low operating temperatures.

Tabular data and curves relating to starting are presented. Sludge is more dangerous in cold-weather operation, and the importance of selecting a quality non-sludging oil is emphasized. Tests to determine the causes of sludging are described, and the five conclusions reached are stated.

The indications that wear is due to corrosion, rather than to removal of lubricant from cylinder walls, are analyzed. With regard to kerosene and Diesel engines, the author states that it seems reasonable to believe that the effect of operating temperatures, as such, with resultant moisture condensation, will result in at least equal relative wear to that which obtains in the gasoline engine.

In conclusion, seven general rules are stated whereby the utmost satisfaction may be obtained during operation at low temperatures.

IN every type of automotive operation, the performance of the engine at low temperatures is becoming increasingly important year by year. Improved highways with state and city facilities for keeping them open in even the worst winter-weather have tremendously increased passenger-car, bus and truck operation in cold weather; air lines now operate throughout the year; tractors are rapidly replacing horses and a large part of their operation comes when temperatures are low; the railroads in all probability will greatly increase their automotive equipment and the problems of cold-weather operation will interest them vitally. The marine engine, particularly in the northern salt waterways, has always had its share of cold-weather problems.

Considerable attention has been devoted to the problem of cold-weather starting as affected by fuels and lubrication, but there is very little in the literature devoted to other phases of operation during that period between starting and the fully warm engine, and the effect that atmospheric temperature may have on long-time engine-performance. This paper will be devoted to these problems arising from the operation of engines at low temperatures.

In general, four phases of engine operation are of vital importance to the operator when low temperatures are encountered; they are: Starting, oil pumping (circulation), sludging, and wear. To these might be added, for certain types of operation and for the discriminating operator, quick warming up, as pertaining to fuel quality. While this is of vital importance to the quality-fuel buyer, this discussion will center chiefly with those factors which influence maintenance rather than operating performance; consequently, this fifth phase of low-temperature operation will not be considered specifically.

Starting

This paper would be incomplete without some data on the starting problem *per se,* although much has been written on the subject. New light is being thrown on this problem through the activities of the Society in establishing tentative specifications for winter-grade motor-oils, and by the petroleum industry through the introduction of new types of lubricants and fuels designed to give easy starting combined with safety at high operating-temperatures.

Previously reported data[1] showed that the starting equipment on the average engine was adequate to permit cranking the engine at the minimum speed (40 r.p.m.—although the skillful driver can start a well-adjusted easy-starting car at slightly below 30 r.p.m.) provided the oil in the crankcase has a viscosity below 30,000 sec. Saybolt-universal viscosity at the existing temperature. Subsequent developments have necessitated a readjustment of the foregoing for the following reasons:

(1) It has been found that the torque necessary to crank an engine is a function of temperature as well as of oil viscosity. This probably is due to the fact that the various metals used

[This paper was presented at the Tractor and Industrial Power Equipment Meeting of the Society, Chicago, Dec. 6, 1934.]

[1] See S.A.E. JOURNAL, February, 1928, p. 213; Wilkin, Oak, and Barnard; February, 1931, p. 234, Blackwood and Rickles; August, 1931, p. 141, Kent; September, 1931, p. 210, Larson; and July, 1934, p. 238, Graves, Mougey, and Upham.

Table 1—Torque Requirements as Affected by Temperature and Viscosity

A.S.T.M. Oil Viscosity	Torque Required, Lb-Ft. at Deg. Fahr. —15	0	+25
15,000	45	42.5	40
20,000	62	56.0	50
30,000	80	67.0	61
40,000	90	73.0	70
50,000	101	79.0	77

in engine construction have different expansion coefficients and a certain amount of distortion and change of clearances occurs when temperatures change. For example, the torques given in Table 1 were required to crank a given engine at 40 r.p.m. Comparable figures have been found to exist on many other engines.

The data in Table 1 show that, as temperature decreases, there is an increase in the internal friction of the engine in excess of that caused by oil viscosity alone. This friction is due to partial-film lubrication and possibly some metal-to-metal contact at certain points tending to cause wear. It is interesting to note that the oil having the lowest viscosity at the existing temperature gives the lowest increment of friction as temperature drops; hence, the greater insurance of minimum wear, because, in tight-fitting locations, the lower-viscosity oils have the best chance of giving adequate lubrication.

(2) It is now recognized[2] that the decrease in battery efficiency at low temperatures markedly affects the permissible oil viscosity at starting temperatures. If we assume that full battery output is available at 80 deg. fahr., the output at lower temperatures will be as given in Table 2.

(3) Tests made at the Standard Oil Development Co.'s laboratories within the last few months on several 1934 automobiles have demonstrated that, with the starter equipment on the larger and more powerful engines now being used in automotive service, higher torques are required than for the cars existing when the 30,000-sec. figure for critical viscosity was tentatively set. A conservative figure for critical viscosity for the average modern high-speed high-powered engine to permit starting at 0 deg. fahr. is 23,000 sec. Saybolt.

To cover more adequately all geographical locations, and seasonal operation in any one territory, the curves in Figs. 1 and 2 present a composite of the foregoing three factors and show the maximum permissible viscosity for the average car as a function of existing temperature.

Fig. 1 is a plot of the data given in Tables 1 and 2. If 23,000-sec. Saybolt-viscosity at 0 deg. fahr. is the limiting viscosity for the average car, and the data in Table 1 are representative of change of required torque with temperature, we may superimpose upon the sheet the output curve of a starter system capable of delivering the required torque at 0 deg. fahr., and torques at other temperatures as calculated from Table 2.

Fig. 2 is a plot of maximum permissible viscosity for the average car as determined by the intersection of the required torques and available starter torques in Fig. 1. Curves are shown both for electric-starter and also for hand cranking. For the latter, it is assumed that the average engine can be hand-cranked at the required 40 r.p.m. when oil viscosity is 18,000 sec. Saybolt at 0 deg. fahr. Hand-cranking tests have shown this to be substantially correct. These curves assume, and justifiably, that the minimum cranking speed of 40 r.p.m. does not change with temperature since this speed is required to lift fuel out of the carburetor jets and deliver it to the combustion chamber to be burned. Neither have we considered the possibility of high battery-drain reducing battery-terminal voltage to a point where the ignition system fails to deliver a spark. This is a rare occurrence on modern engines.

Table 2—Temperature Effect on Battery Starter-Output

Temperature, Deg. Fahr.	Percentage of Normal Starter Torque
80	100.0
40	93.8
20	87.9
0	75.2
—10	66.2
—15	61.4

Oil Pumping

It has been demonstrated by various investigators that most oils will pump freely in a crankcase only down to their pour-point, although some oils will pump down to about 10 deg. below their pour-point. This fact is so well recog-

[2] See S.A.E. Journal, July, 1934, p. 238; Graves, Mougey, and Upham.

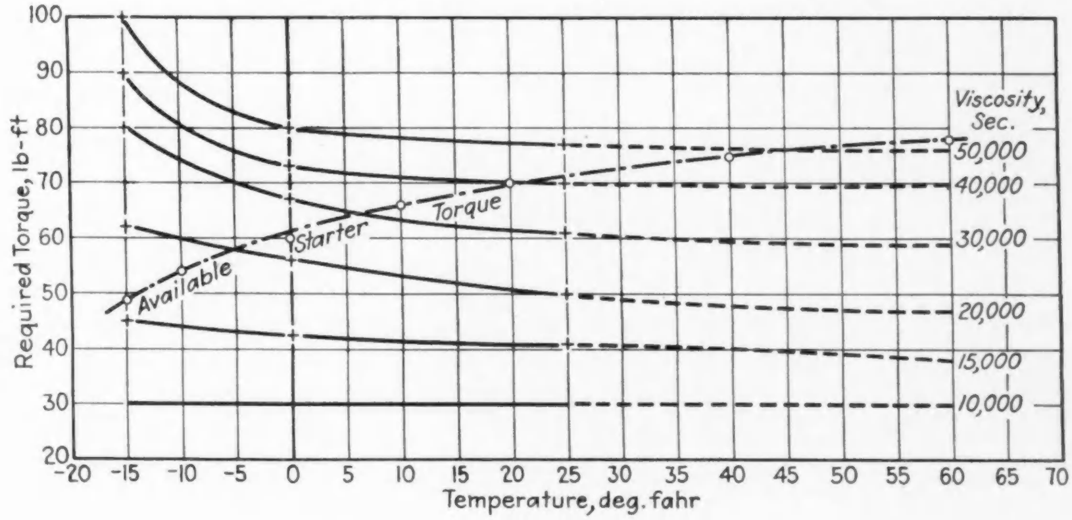

Fig. 1—Required and Available Torque as Dependent upon Temperature and Oil Viscosity

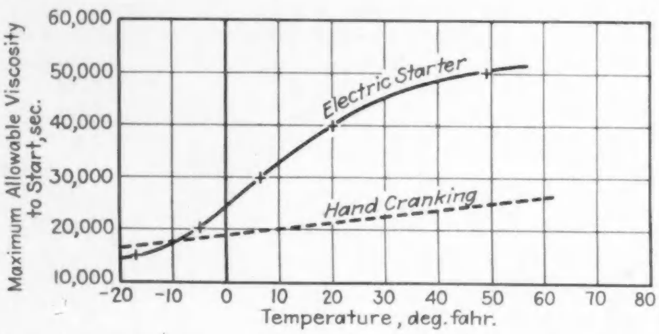

Fig. 2—Maximum Starting Viscosities at Various Temperatures

nized now that all winter oils marketed by reputable companies carry a pour-point low enough to assure pumping in cold weather. It has not been recognized heretofore, however, that some oil-pumping systems cannot handle even low-pour-point oils if the viscosity of the oil exceeds about 35,000 sec. Saybolt. This is particularly true of pumps located above the oil level. Oil of this viscosity does not flow freely and, after the oil in the immediate vicinity of the pump inlet or inlet tube has been removed, air begins to get into the pump inlet and frequently the flow of oil ceases entirely when the pump gets air-bound.

This leads to the conclusion that, at temperatures of 15 deg. fahr. or below, if the engine can be started there is reasonable assurance that the oil is circulating—since the viscosity must be below 35,000 sec. to start at 15 deg. fahr.; see Fig. 2—provided of course that the pour-point is at or below starting temperature. However, above 15 deg. fahr. an electric starter is capable of starting the engine when the viscosity exceeds 35,000 sec. and there exists the possibility of suffering serious engine damage and excessive wear as a result of non-pumping. This is particularly apt to be the case in fall weather before heavy oil has been replaced by the proper cold-weather grade. It is interesting to note that, for hand cranking, if the engine can be started, there is automatic assurance that the oil will be low enough in viscosity to circulate since it is well nigh impossible to crank an engine fast enough to get started if the viscosity of the oil in the crankcase is above 35,000 sec. Saybolt.

Sludging

This phase of engine operation is receiving close attention from both engine builders and petroleum technologists. When sludge occurs, there is danger of clogging oil screens, oil lines, bearing grooves and piston rings, resulting in excessive engine wear and in extreme cases actual failure of bearing or scored pistons and cylinders.

Sludge is more dangerous in cold-weather operation than in warm-weather operation and, for cold operation, the importance of selecting a quality non-sludging oil cannot be overestimated. If sludge occurs in hot operation, it does one of two things, depending upon the nature of the oil and the engine operating conditions. First, it may stay suspended in the oil to give it a black color, in which case the oxidized materials are circulated with the oil. These materials are further oxidized in the ring zone to give, ultimately, ring sticking and are centrifuged in drilled crankshafts and bearings to completely clog the oil lines occasionally. Second, the sludge may settle out of the oil to form deposits in the crankcase. This has one questionable advantage in that, if the material settles out of the oil, less oxidized material will be circulating through the engine to give the troubles enumerated. It has been my experience that, when sludge settles out in the crankcase, the operator rarely has trouble with sticking rings and burned bearings; whereas, when bearings burn out or pistons score or have stuck rings, there are usually no excessive sludge deposits in the crankcase, except where water is present in the oil.

Cold-weather operation results in condensation of water vapor inside of the engine. The oxidized materials in used oil readily emulsify with this water to form pasty masses of semi-solid sludge. This has long been recognized and needs no further description; however, one important result of this was discovered during the unusually cold weather on the Eastern Seaboard last winter. A fleet operator using third-grade oil complained that his trucks were leaving the unheated garage showing oil pressure and that, within 2 or 3 miles, the pressure would drop to zero. Several bearings had burned

Table 3—Effect of Engine Condition on Sludge Accumulation

Test No.	Changes Made in Engine	Temperature, Deg. Fahr.		Engine Inspection at End of Test	
		Jacket Water	Valve Cover	Valve Compartment	Crankcase
1	Engine in poor mechanical condition but in normal adjustment	150	91	Medium-emulsion sludge	Heavy-emulsion sludge
2	Install new valves and valve guides. Other conditions unchanged	159	94	Practically no sludge	Practically no sludge
3	Replace piston rings. Other conditions as in Run No. 2	150	106	Practically no sludge	Indications of sludge[a]
4	Run cold water-jacket. Other conditions the same	84	62	Light-emulsion sludge	Medium sludge
5	Replace old valves and valve guides. Other conditions as in Run No. 31	150	97	Medium-emulsion sludge	Indications of sludge
6	Heat valve cover	150	170	Practically no sludge	Indications of sludge
7	Replace new valves and guides; cold jacket	86	90	Light-emulsion sludge	Medium sludge
8	Same as Run No. 1 but in good mechanical condition	150	125	Practically no sludge	Practically no sludge

[a] New piston rings probably not yet giving a good seal.

Fig. 3—Sludge Emulsion on an Oil-Pump Screen

out on the first unusually cold morning and on the next day the loss of pressure was observed. When the units were returned to the garage they were again showing normal pressure and, when the crankcases were dropped, no sign of screen clogging was apparent. Finally, one of the crankcases was dropped and immediately the pressure gage showed a drop in pressure and the screen was found to be coated with ice crystals. The finely dispersed water in the form of a weak emulsion had frozen and the particles were drawn to the screen by pump suction, eventually blocking the screen. This apparently occurred only in zero weather or colder. Subsequently, other cars were examined and it was found in many cases that ice crystals were collecting on the oil screen and that, whether this accumulation reached serious proportions or not before the engine temperature became high enough to melt the ice, depended largely upon the size of the oil screen. Fig. 3 shows an oil screen coated with an emulsion sludge and it is obvious that oil cannot flow freely to the oil pump. Engine designers should provide adequate pump-screen area and not use too fine a mesh.

A series of tests was then undertaken to ascertain the source of the water and how it might be reduced. Simple calculation showed that the normal breathing of the crankcase through the vent could hardly account for all of the water found in the crankcases, even assuming that saturated air in a heated garage was chilled to zero and the process repeated several times. The only other conceivable sources were leakage of combustion gases into the crankcase past leaky piston-rings, and leakage of these gases past worn exhaust-valve guides into the valve chamber.

A Chevrolet engine in unusually poor mechanical condition was selected for the tests. An oil of known poor-sludging quality was selected for the lubricant. Then followed a most interesting series of experiments. During the series of tests it became desirable to construct a water jacket on the outside of the overhead-valve cover to control the temperature of the valve-rocker-arm chamber. This special cover is shown in Fig. 4. Each test consisted of 35 hr. at a speed and load corresponding to 40 m.p.h. on level road, running for 50 min. and idling for 10 min. of each hour. Oil temperature was held at 160 deg. fahr. The results for each successive test are shown in Table 3. The conclusions to be drawn from these results include the following:

(1) Mechanical condition of the engine primarily determines the degree to which emulsion sludges will collect.

(2) Loose-fitting exhaust-valves and worn valve-guides permit combustion products to reach valve chambers. Valve-chamber covers or plates usually provide a cold surface to condense moisture from combustion products.

(3) Cold cylinder-jacket water is inducive to condensation of water in the crankcase.

(4) Leaky piston-rings permit blowby into the crankcase and water may condense on cold surfaces, resulting in emulsion sludges in the crankcase.

(5) If all engine surfaces are kept reasonably hot, the water vapor which gets into valve and crankcase compartments escapes from the ventilators or breathers before it can condense.

Fig. 5 is a curve showing the condensation temperatures at atmospheric pressure for combustion products when operating at various air-fuel ratios. These valves are calculated for an average fuel having 14.5 per cent by weight of hydrogen and on the assumption that dry air enters the carburetor. It is seen that combustion products which leak into and fill the crankcase and valve chambers begin to condense out water if they come into contact with a surface at from 120 to 145 deg. fahr., depending upon carburetor adjustment. A humid atmosphere in summer weather may increase these condensation temperatures by about 10 deg. fahr. due to the increased amount of water in the combustion products. The humidity effect is negligible in winter weather, when absolute humidity is necessarily low.

For existing engines which are subject to water accumulation in the crankcase and emulsion-sludge formation with its dangerous possibilities, the first step to remedy the condition is to use a non-sludging lubricant and to replace valves, valve guides and piston rings. The second is to provide means for keeping the air in the vicinity of the engine at a reasonably high temperature by the use of radiator covers, thermostatic shutters and reduction of bottom ventilation of the engine, to keep engine surfaces warm enough to prevent moisture condensation on the inside surfaces.

For the engine manufacturer, there is indicated a necessity for better materials and better design to reduce valve-stem and valve-guide wear; better piston-ring design to decrease blowby; means of ventilating crankcases and valve chambers so that moisture does not condense therein, and, coincident with this,

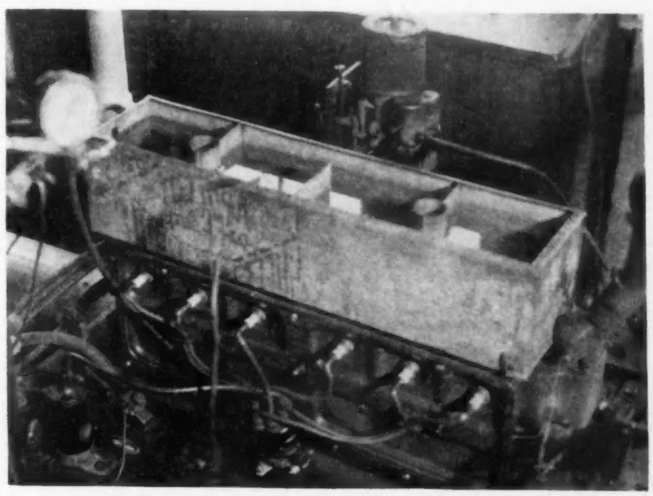

Fig. 4—A Water Heater for a Chevrolet Valve-Chamber Cover

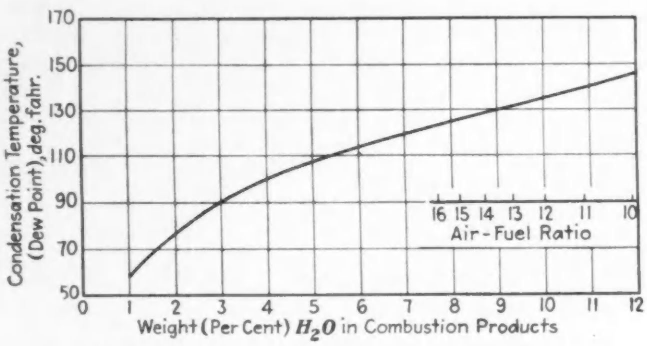

Fig. 5—Curve Showing Temperatures at Which Water Will Condense at Atmospheric Pressure

a cooling and under-hood-ventilation design which will maintain reasonably high engine-surface temperatures even in cold weather. Intermittent service in cold weather gives the most trouble in this regard and offers the most difficult problem of solution.

Efficient oil filters, while minimizing the trouble, cannot remedy it entirely since acidic bodies entering the crankcase with fuel dilution are usually excellent emulsifying agents and emulsions may form even in the absence of oxidized carbonaceous particles in the oil. Further, when freezing weather occurs, there is danger of the freezing of water particles and resultant engine damage. The only safe recourse for the operator at present is to drain and refill the crankcase at frequent intervals in very cold weather with an oil of low sludging-tendency.

Wear

There has long existed among automotive engineers a belief that engine wear was highest during cold-weather operation. Indeed, laboratory tests and a wealth of practical experience by operating people left little doubt that such was the case. Until more or less recently, this increased wear was largely attributed to the use of the choke in starting and warming up and the resultant thinning out and washing off of the oil on the cylinder walls. However, recent investigation, while substantiating the fact that wear is high in cold weather—higher even than had been believed—indicates rather strongly that the major part of the wear is not caused by the removal of lubricant from cylinder walls, but rather to corrosion.

In March, 1933, Ricardo[3] presented a paper in London giving the first clear-cut version of the corrosive wear-theory. Briefly this was to the effect that, at the moment the piston reached the end of its stroke, the oil between the ring and cylinder was squeezed out; then, as the piston moved on the return stroke, the cylinder was wiped clean until the oil film could be re-established. Hence, on each stroke, a clean surface—unprotected by oil film—was exposed to the chemically active products of combustion and rapid corrosion occurred. The succeeding piston stroke removed the corroded material and the process was repeated. Several observations were mentioned tending to indicate that it was not primarily the abrasive action of the rings, perhaps the strongest argument being the observation that in the case of the sleeve-valve engine where relative movement between cylinder (sleeve) and piston ring is never zero—and the oil film is not broken—the wear at the top of the piston travel is only a small fraction of that for the conventional engine.

A few months later the first interim report[4] of the Institution of Automobile Engineers Research and Standardization Committee on Cylinder Wear was published, lending valuable technical support to Ricardo's theory, and offering perhaps the first sound technical data on the effect of operating temperature on cylinder wear. With the recent publication of the second report of this committee[5] there exists in these two articles probably the best available published data on the causes of cylinder wear.

Of particular interest at this time is that portion of their work which relates wear to low operating-temperature. It is first shown that the lubricating oil could be diluted up to 90 per cent before there was a noticeable increase in wear, although other troubles were encountered with the engine. While the use of the choke may dilute the oil on the cylinder wall more than 90 per cent, the data lessen the probability that the over-use of the choke in starting and warming up is responsible for the increased cold-weather wear. In succession, they ran tests to determine the effect of reduced lubrication, high cylinder-wall temperature, load, speed, starting and stopping, and in no case did they find excessive wear. However, when operating at reduced cylinder-wall temperature, excessive wear resulted. For example, the wear was found to be eight times greater at 122 deg. fahr. cylinder-wall temperature than at 212 deg. fahr. In general they found that, above approximately 194 deg. fahr. the cylinder wear was not excessive; whereas, below that temperature, wear increased rapidly.

That this increase in wear is due to the corrosive action of combustion products accelerated by the condensation of water on the cold surfaces seems amply justified. In 1924, Clayden[6] was able to collect 10 cc. of water per cylinder during a 10-min. warming-up period. The I.A.E. report referred to shows that hydrogen fuel run at low temperature gives less than half the wear of a gasoline fuel, showing that the water condensation alone is insufficient to give excess wear.

It is further stated that the amount and quality of lubricating oil on the cylinder wall during cold starting and cold-running operation markedly affects the total amount of wear, the wear decreasing as the amount and quality of the oil increases. We would point out that, since wear decreases with increased amounts of oil, this is a strong recommendation for using 10-W and 20-W motor-oils for winter operation quite aside from ability to start. Further, since the thickness of the oil film, or quantity of oil, on the cylinder wall at the time the engine is started is in large part dependent upon what its viscosity at high temperature is—since engines are shut down hot and a low-viscosity oil drains from the cylinder walls more completely—the importance of high viscosity-index is immediately apparent. The higher the viscosity index is, the higher is the viscosity at high temperature for a given "easy-starting" viscosity at low temperature. This is verified by the work[7] of H. H. Langdon, who has shown that engine wear is decreased up to 54 per cent by using oils of high viscosity-index.

To give a more practicable interpretation to the I.A.E. report as regards the effect of starting temperature on cylinder wear, their data have been replotted on semi-logarithmic paper and are shown in Fig. 6 in terms of water-jacket tem-

[3] See *Journal of the Institution of Automobile Engineers*, March, 1933, p. 13 and June, 1933, p. 45; Ricardo.
[4] See *Journal of the Institution of Automobile Engineers*, June, 1933, p. 73; Williams.
[5] See *Journal of the Institution of Automobile Engineers*, August-September, 1934, vol. 2, No. 10, p. 19; Williams.
[6] See S.A.E. JOURNAL, July, 1924, p. 47; Clayden.
[7] See Bulletin No. 41, 1933, Engineering Experiment Station of Washington State College; Langdon.

Table 4—Relation between Cylinder-Wall and Jacket-Water Temperatures

Load	Cylinder Wall Temperature at Top of Piston Travel, Deg. Fahr.
Full	Jacket Temperature + 72 Deg. Fahr.
Half	Jacket Temperature + 62 Deg. Fahr.
Quarter	Jacket Temperature + 52 Deg. Fahr.

perature in degrees fahrenheit rather than cylinder-wall temperature in degrees centigrade, and extrapolated to 0 deg. fahr. While the oil used may and does affect the wear, it is probable that, within reasonable limits, the *relative* wear at low temperatures compared to normal operating wear is substantially the same for all oils. To make this conversion to jacket-water temperature, it has been necessary to determine the relation between cylinder-wall and jacket-water temperatures. Tests made at the Standard Oil Development Co.'s laboratories show that at the top of the piston travel—opposite the top ring of the piston, where the cylinder wear is the greatest—the difference between jacket-water temperature and cylinder-wall temperature is substantially independent of speed and varies with load as shown in Table 4.

Since, during the starting and warming-up period, engine load is rarely in excess of 30 per cent of full load, the conversion of the I.A.E. data is based on a differential of 50 deg. fahr. at the end of the warming-up period. Further, if starting occurs at 0 deg. fahr., the differental is zero degrees. Inasmuch as the I.A.E. data are for continuous operation at the respective temperatures, and in practice the engine temperature increases from starting temperature to normal running temperature during the warming-up period, it is possible to approximate the relative wear which occurs during a single start and warming-up, and the equivalent "additional miles" of wear, by combining the rate of increase of jacket-water temperature with the rate of wear as affected by temperature, assuming cooling-water temperature and jacket-water temperature equal at the start and differing by about 50 deg. fahr. when fully warmed up.

The rate of warming-up is shown in Fig. 7, which is a composite of data from several cars run on the Standard Oil Development Co.'s cold-room rear-wheel dynamometer. Each car was started at 0 deg. fahr. and warmed up at approximately 25 to 35 m.p.h. with cold air being delivered against the radiator at equivalent car speed. Hence the figures are representative of average road practice for zero weather, although some thermostatic systems warm up the engine at an appreciable faster rate.

By dividing this warming-up curve into ½-min. increments and reading the average temperature over each ½-min., then reading and tabulating the wear/1000 miles from Fig. 5, and making the necessary calculation to reduce this wear per 0.25 miles—traveled in ½ min. at 30 m.p.h.—a figure for total wear is obtained. For the illustration shown, the calculations show that:

(1) Starting and warming up an engine at 0 deg. fahr. results in 13.2 times the wear which would have occurred had operating temperature been normal. (If the engine did not warm up during this 20-min. period, the wear would have been about 85 times normal wear.)

(2) Each start and warming-up at 0 deg. fahr. is the equivalent of 130 miles, or an additional mileage during the 20-min. warming-up at 30 m.p.h. of 120 miles which do not show on the odometer life of the car.

The significance of these results will depend largely upon what the normal wear for a given engine may be. This normal wear will depend in turn upon design, rings, size, fuels and lubricants used. In the case of the modern passenger car, the increased wear during starting and warming up is probably of little significance as shown by the following data on engines in the lowest-priced cars on the market.

(1) An eight-cylinder car in everyday road service showed an average cylinder-wall wear of but 0.0008 in. in 32,165 miles.

(2) A six-cylinder engine on dynamometer test at 50 m.p.h. equivalent speed showed a cylinder wear of 0.00133 in. in 14,000 miles.

(3) An eight-cylinder engine on dynamometer tests at 40 and 50 m.p.h. equivalent speed for 42,000 miles, plus 22 cold-starting and warming-up tests from 0 deg. fahr. and −15 deg. fahr., showed, at the end of the operation, an average wear of 0.00194 in. per cylinder.

It might be concluded from this analysis of the cold-starting wear-problem that its importance lies not in the extra wear occurring during the starting period but rather in sustained operation at low engine-temperatures.

Engine builders are providing two types of thermostatic control of jacket-water temperature, one system bypasses the radiator and results in quick warming-up of the jacket water due to the lesser volume of water to be heated. The other closes radiator shutters and circulates the full amount of water at all times. This warms up the engine more slowly; but it has a decided advantageous feature in that engine-surface temperatures are kept warmer, thus reducing the probability of emulsion-sludge accumulation. A combination of both systems would provide the minimum of wear during the warming-up period plus reduction in the probability of excessive emulsion-sludge accumulation.

There are other factors entering into engine operation at low temperatures which are worthy of close consideration,

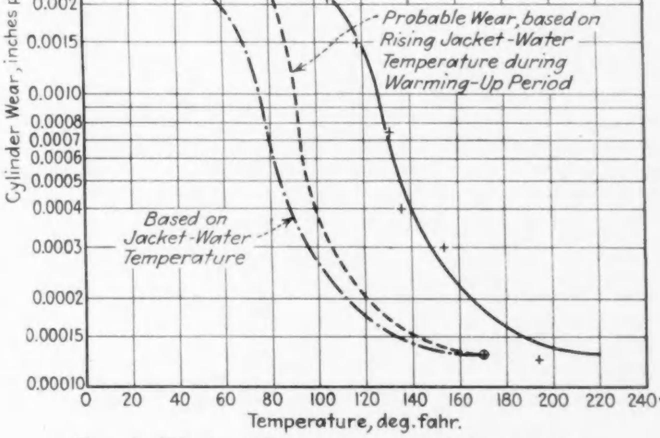

Fig. 6—Effect of Temperature on Cylinder Wear

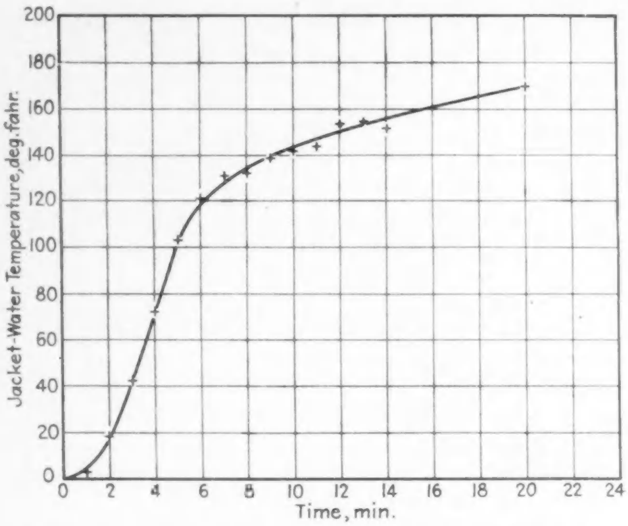

Fig. 7—Average Rate of Warming-Up of Passenger-Car Engines

factors which may contribute to low-temperature wear to an extent that values may be several fold the figures given in the preceding paragraphs. Some of these are:

(1) Abrasive material in the oil will greatly accelerate wear, and this may be particularly significant under starting and warming-up conditions where the amount of lubricant reaching the rubbing surfaces is far below normal. An efficient oil filter is of great value in minimizing this possibility. Lacking such, it is desirable to change oil frequently in winter operation, and this is particularly true in cases where moisture collects in the crankcase.

(2) Williams[8] has shown that CO_2 in the presence of moisture forms carbonic acid which, in turn, causes rapid corrosion and wear of cylinder walls and piston rings. Since CO_2 is one of the principal products of combustion, it is important to prevent its conversion to carbonic acid by reducing the condensation of the water vapors in combustion products. It will be seen from Fig. 5 that, for lean mixture-ratios, water condenses at higher temperatures than for rich mixture-ratios; and, at the same time, the CO_2 content of the exhaust gases is higher for lean mixtures, both contributing to corrosion-wear probability.

(3) It is popularly believed, and has been frequently stated that high-sulphur fuels cause rapid wear. Present knowledge on this point does not permit of making any such broad statement, even for low-temperature operation. Some of the West Coast gasolines are high in sulphur, and yet have given excellent performance for many years in areas experiencing bitter cold weather. On the other hand, there have been evidences of poorly refined gasolines from low-sulphur crudes giving excessive corrosion. On the whole question of sulphur in the fuel, the best assurance which the operator has for obtaining good performance is to purchase his fuel from reputable marketers.

(4) Gasoline fuels vary widely in their "warming-up" characteristics, and one which permits quick application of load without the necessity for using the choke will be of material aid in reducing warming-up time. Both sludging and wear are lessened as a result.

[8] See *Journal of the Institution of Automobile Engineers*, August-September, 1934, vol. 2, No. 10, p. 19; Williams.

[9] See *Journal of the Institution of Automobile Engineers*, August-September, 1934, vol. 2, No. 10, p. 19; Williams.

[10] See Bulletin No. 20, June, 1934, p. 93; School of Engineering, Pennsylvania State College.

The recent interest in the use of alcohol blended fuels brings up the question of their effect on engine wear. Data in this respect[9] show that, at the lower operating-temperatures, ethyl alcohol of the order of 15 to 20 per cent in gasoline results in approximately twice the wear as the same gasoline without alcohol, although at high temperatures there is no difference in wear. This increase is attributed to the formation of certain organic acids in the combustion of the alcohol.

Kerosene and Diesel Engines

So far, only gasoline engines have been discussed. What the situation is with respect to the kerosene-burning engines and the Diesel, it is difficult to say. It seems reasonable to believe that the effect of operating temperatures, as such, with resultant moisture condensation, will result in at least equal relative wear to that which obtains in the gasoline engine. The effect of the chemical composition of the fuel, particularly with regard to sulphur content, is more difficult to estimate. It is well known that some Diesel engines, particularly the two-cycle engines, are suffering from excessive wear; and it is significant that most of the service where high wear is occurring is in marine work where jacket-water temperatures are normally maintained at lower values than for industrial, tractor and automotive service. Sulphur content of Diesel fuels is well above that for gasoline, usually being in excess of 0.50 per cent and normally running around 1 per cent for this type of service. Some are as high as 3 per cent sulphur. For the most part, wear is not prohibitive and this may be due to the protective effect of this type of fuel, providing a film of fuel oil on the cylinder walls and thereby reducing corrosive possibilities. Also, the cylinder-wall temperatures of the Diesel are of necessity somewhat higher than for the gasoline engines, which also contributes to less wear from the corrosive-wear theory.

It has also been stated[10] that the use of Diesel fuels of low ignition-quality will result in increased cylinder wear. This might well mean also that, even for fuels of good ignition-quality, wear might be excessive under operating conditions where temperatures were not high, such as during idling or in certain marine services.

In conclusion, to give the utmost satisfaction during operation at low temperatures, the following general rules might be suggested:

(1) Use a motor oil of proper viscosity at starting temperatures to assure easy starting.

(2) To minimize wear during starting, use the highest possible viscosity index. This will also assure optimum protection at high operating temperatures.

(3) Warm up as quickly as possible. This may be accelerated by thermostats, radiator shutters, rapid application of load, and the like.

(4) Use only quality lubricants to minimize sludge formation.

(5) Maintain engines in good mechanical condition, particularly with respect to piston rings, valves and valve guides, and oil filters.

(6) For the greatest protection, use only quality branded fuels.

(7) Engine builders might well give more thought to the possibilities of incorporating in design the use of non-corrosive steels; improvements in design to prevent blowby past pistons and valves; incorporation of features to speed up the warming-up period; and provide means of maintaining reasonably high engine-surface temperatures in cold weather.

News of the Society

Management Precepts Proposed by G. V. Orr

• So. California

At the Jan. 11 meeting, 72 members and guests attended the technical session and 58 were present at the dinner which preceded it. The speakers and subjects were G. V. Orr, Regional Manager, Chrysler Sales Corp., who spoke on The Automobile Today and on Management Relationships; J. R. Barton, who showed a motion picture of the Chrysler Plant, and Paul W. Gaebelein, plant manager of the Chrysler Corp., who answered questions. The prominent discussers were Walter Hall, E. E. Tattersfield, C. T. Austin, E. R. Jackson, W. Linville, W. S. Smith, F. W. Gardner, C. F. Lienesch, Carl Abell and Frank R. Elliott.

Following, are some of the precepts advocated by Mr. Orr:

For the Executive

The "Boss" cannot think one way and act another.

Avoid the "I" disease. Make it a "We" organization.

A real executive earns because of what he *gets done,* rather than what he does.

A man accomplishes most when some appreciation is shown for his work and ideas.

A good manager is not prejudiced by shortcomings that are emphasized through close association.

For the Employe

Obey orders.

To serve well, an employe must have peace of mind.

Be enthusiastic. An employe must have a real desire to be of service.

Honor the "Chief."

Other points advocated were: Say it on paper. Suggest what to *do,* not what *not to do.* Delegate authority with responsibility. Constructive criticism increases a firm's assets; destructive, its liabilities. If you want an employe interested in you and your business, take an interest in him and his. When any one fellow really tries to help another, he cannot help but help himself.

Traffic is Subject Of Three Speakers

• Baltimore

The Jan. 3 meeting of the Baltimore Section was held at the Engineer's Club, 65 attending the dinner and 102 being present at the technical session. A symposium on traffic and safety was presented, the speakers being Paul L. Holland, chief engineer, Public Service Commission, and Preston D. Callum, general chairman, Baltimore Safety Council; chairman, Baltimore Traffic Committee; and secretary, Warfield-Roloson Co., Inc.

The meeting was conducted by Adrian Hughes, Jr. The most prominent discussers were: Gen. Charles D. Gaither, Commissioner of Police; Bernard L. Crozier, chief engineer, City of Baltimore; Robert M. Reindollar, assistant chief engineer, State Roads Commission; and Judge Joseph F. DiDomenico of the Traffic Court of Baltimore.

Section Endorses Inspection Work

• Oregon

The Oregon Section meeting on Dec. 14 was held at the Refining Industries Plant at Portland. The dinner attendance was 79 and 89 were present at the technical session.

The Section endorsed a compulsory inspection system which was proposed by R. W. Mann who asked that a motion be made by the Oregon Section accordingly. This motion was seconded by A. R. Trombly and carried by a unanimous vote. This endorsement was for a compulsory inspection at least twice a year of all motor-vehicles in the state for mechanical requirements of safety. The endorsement, which will be forwarded to the Oregon Safety Committee, came as an aftermath of discussion following a talk by J. Verne Savage, superintendent of municipal shops, in which he cited facts and statistics regarding mechanical safety of the average motor-vehicle, founded on his recent experiences supervising Portland's safety lanes.

This safety inspection showed the following official summary of the Oct. 15-Nov. 16 safety inspection conducted by the Portland trade in conjunction with the "Let's Quit Killing" campaign sponsored by The Oregonian and the Oregon State Motor Association. The figures were released by the Motor Association. There was an average of 308 cars tested a day and 8866 cars were tested, of which 4751 were passed O.K. and 4115 were rejected because of some defect in mechanical equipment.

The following defects were found: License plates, 4 per cent; operator's license, 2 per cent; brakes, 17 per cent; wheel alignment, 8 per cent; lights, 37 per cent; tires, less than 1 per cent; windshield swipe, 96 per cent; rear-view mirror, less than 1 per cent; horn, less than 1 per cent; windshield vision, less than 1 per cent; muffler, less than 1 per cent; steering mechanism, less than 1 per cent. On 10 per cent of cars tested, both braking and lighting defects were found.

That the disrepute in which reclaimed oils stand is due to haphazard methods so often used in their re-refinement, was the conclusion drawn by S. C. Schwarz, chemist of Refining Industries, in the second talk of the evening. "The biggest fault of reclaimed oils is sediment," Mr. Schwarz claimed. "The average small plant is not equipped to eliminate this or to make accurate tests as to the reliability of the finished batch. Oils do not wear out, and if the re-refinement is conducted scientifically, may be reclaimed to good advantage."

Presentation to Oregon State College of a butane carburetor and a display panel showing oil in the various stages of refinement was a third feature of the meeting. The carburetor was received from the Holzapfel Instrument Co., Los Angeles, and the panel from the Texas Oil Co.

Bushnell Gives Paper On Automotive Oils

• Northwest

Oil consciousness as a means for reducing misuse and abuse of lubricants was advocated by Sherman W. Bushnell, chief engineer, Automotive Engineering Co., Seattle, in a paper at the Jan. 11 meeting of the Northwest Section. Beginning with some more or less elementary definitions and explanations of friction and its laws and of the physics and chemistry of oils, Mr. Bushnell led up to the vital characteristics of lubricating oils. As the three most significant properties of automotive lubricants the author cited viscosity, stability and oiliness, quoting H. C. Mougey, of the General Motors Research Laboratories.

After defining viscosity and the units of its measurement, Mr. Bushnell discussed the effects thereon of pressure and heat. The viscosity of mineral oils increases considerably with pressure—up to 1500 per cent at 15,000 lb. per sq. in.—which is of real practical value in cases of sudden or unusual bearing overloads. The viscosity of all oils falls rapidly with increase of temperature. Different oils behave differently in this respect which may be evaluated with the help of the Viscosity-Temperature Chart of the American Society for Testing Materials. A reproduction of this chart was attached to the paper. By plotting viscosities at two temperatures on the chart a straight line through these two points may be drawn to indicate by its slope the magnitude of the change in viscosity with temperature of the particular oil under consideration. Oils may be classified in this respect by the so-called Viscosity Indices which are readily determinable with the help of another chart appended to the paper.

The importance of viscosity becomes apparent when one considers its effects. At low temperatures the ability of the oil pump to pick up the oil in the crankcase is dependent on its viscosity. In one instance, starting at 28 deg. fahr. it took over 11 min. before any oil reached the top ring of the piston. "Think what was happening all that time to the rings, cylinder walls, valve gear, etc., to say nothing of the bearings," Mr. Bushnell emphasized. At high temperatures the viscosity becomes the limiting factor which determines the load a bearing will carry. It is important that the viscosity be low when the engine is cold and high when it is hot. Unfortunately oil works the other way; hence, the importance of selecting an oil with a high viscosity index.

The usual method for measuring viscosity is by the Saybolt viscosimeter whose drawback is the impossibility of testing other than perfectly clean oils. Mr. Bushnell and George E. Bock have developed a machine for measuring accurately viscosities of any liquid regardless of the amount of solid matter which it may

contain. It reads directly and is very much faster than the Saybolt type of viscosimeter.

Since engines are lubricated by means of a large supply of lubricant which is used over and over again the question of stability is important. The change in viscosity with temperature has been mentioned as one change which occurs in service with all oils. The changes in specific gravity, flash and fire points, volatility, viscosity as a result of dilution, oxidation, acidity, decomposition, etc., are all matters of stability which change the value of the oil as a lubricant from what it was originally, and thus its ability to resist these changes are a direct measure of its quality. Under stability we should include also any chemical changes by which the oil might cause corrosion, gumming, or excessive carbon. Many of these things may be determined in the laboratory. Mr. Bushnell described briefly the tests and the conclusions which may be drawn therefrom. Others may be found in actual service only.

Two Factors Affect Oil

When it comes to used oil two factors are often mentioned—dilution and solids. Much has been said about dilution, but evidence seems to be lacking to show that under ordinary circumstances it has any bad effects. As a matter of fact there is evidence the other way as we learn how much lighter oils we should be using. When it comes to solids this is a different matter. Solids—carbon, gum, oxides, metallic particles from the motor, road dust, etc.—injected into the fluid film can have nothing but deterring effects. Carbon is the most important. Carbon formed by actual burning and decomposition of both fuel and oil due to high heat is extremely serious. It cannot be eliminated entirely but much can be avoided by the use of an oil which will not decompose too readily and one which is thin enough so that its film thickness on the walls of the combustion chamber and cylinder will be outside the reach of the combustion flame.

Many are familiar with oils sold as upper-cylinder lubricants and motor breaking-in oils which contain what is known as colloidal graphite, said Mr. Bushnell. The same carbon is formed by the combustion of motor fuel. An oil run 500 miles cannot be told under extreme magnification from the product you buy to break in your motor with. If the other pollution could be kept out of the oil in a motor, it would be a shame to change the oil under 10,000 miles and perhaps even then. Colloidal graphite in the right proportion is a great help in breaking in new or rough bearing surfaces. If the oil is to be changed often, a steady diet of graphite in very small quantities is a good thing. If the oil is not changed often, graphite has no value in a motor well broken in. It may be actually detrimental by building a heat barrier at a critical point or clogging small passages or increasing the viscosity of the oil.

Gums themselves are not harmful in a motor in small quantities but they do plenty of damage as a binder for carbon and other solids. Use oils with as little gum forming contents as possible. A good oil filter and a good air filter will keep down road dust and metallic particles. Metal particles in crankcase drainings after a motor is broken in means only faulty lubrication. Oxides are to be kept down by using chemically stable oil and running it cool.

When fluid film lubrication fails the property of oiliness is important. In modern conception it is the tendency of the lubricant to become absorbed in the bearing surfaces thus tending to saturate the attractive forces of the surfaces and to lower their capacity for cohesion. With the exception of a few special cases it has not been definitely demonstrated that oiliness is of any real advantage in the operation of an automobile engine.

Mr. Bushnell illustrated his paper by charts and exhibits of laboratory apparatus, including the new viscosity-testing machine, and samples of oils which have undergone various tests.

The meeting, which was held at the New Washington Hotel, was attended by more than 90 members and guests. John E. Holmstrom presided.

Gruse Describes Gasoline's Points

• Pittsburgh

At the Dec. 6 meeting of the Pittsburgh Section, William A. Gruse spoke informally to 100 members and guests on "Gasoline". Mr. Gruse, a member of the Pittsburgh Section, is director of petroleum research at the Mellon Institute. His talk was particularly interesting to his audience which included many maintenance men and fleet operators.

Defining gasoline as a complex mixture of hydrocarbons, possibly 2,000 or more compounds of the same general series, Mr. Gruse stated that gasoline must fulfill two most important requirements—it must burn—it must have volatility. As to the first requirement, not much is required merely to run a motor vehicle—kerosene, for example, will serve. Volatility, however, affects such important factors as ease in starting, acceleration, economy, and power.

The most satisfactory method of expressing volatility lies in distillation curves, showing per cent of distillation against fahrenheit temperatures. Mr. Gruse discussed in detail the effect of volatility on starting, acceleration, crankcase dilution and vapor-lock. The influence of engine design on the antiknock characteristics of gasoline and the octane ratings is extremely marked, as shown by exhaustive tests on actual motor vehicles of current design. These tests were conducted on the famous Uniontown Hill, using engines of various types. Variations in design showed as high as 20 octane numbers increase for the same gasoline.

The type of engine showing the poorest results from antiknock standpoint was the conventional L-head with flat top. This design apparently does not take advantage of the antiknock potentiality of the gasoline on account of turbulence and long flame travel. Slightly better in performance was the conventional valve-in-head with spark plug on the side. Better still was the Ricardo L-head type, which gave a very favorable performance with apparently less turbulence, less flame travel, and less exhaust gas popping.

Design Increases Rating

The best performance, as far as developing the most favorable octane rating of the gasoline, was observed in a modified valve-in-head type with four valves and a pent-roof cylinder head with the plugs in the center. This design showed an increase as high as 20 octane numbers for the same gasoline used in the other motors. It was noted during these tests, according to Mr. Gruse, that cooling cylinder walls showed an increase as high as two octane numbers. The temperature of the intake manifold seemed to have greatest effect, the octane rating increasing as the manifold is cooled. It was noted also that volumetric efficiency varied according to the octane rating, the determining factor apparently being the amount of exhaust gas left in the cylinder.

In discussing mileage performance, Mr. Gruse stated that this depends on the utilization of the actual heat units (B.t.u.) in the gasoline. The present gasolines vary very little in B.t.u. value. This is evident from exhaustive tests made using different types of gasoline at present on the market. Gasolines of today, of course, are not comparable with the gasolines of ten or twelve years ago in which the end points varied from 417 deg. to 492 deg. The end points of gasolines in common use today vary from 312 deg. to 400 deg. This improvement in gasolines has made possible the operation of more efficient motor designs and very marked increases in compression ratio.

Mr. Gruse stated that increasing compression ratio and maintaining intake manifold temperature at about 50 deg. above the dew point of the gasoline may give an increased performance approximating 38 per cent.

The combustion of gasoline results from what is practically an explosion of the gasoline molecules and involves so many complex changes that they are difficult to follow. The degree of this combustion, however, can be indicated by analyzing the exhaust gasoline, the most common type of analyzer working on the theory of thermal conductivity of the exhaust gas mixture. While the results obtained from the use of the analyzer should be of great assistance to the carburetor expert in making adjustments, they should not be accepted blindly as they are affected by many factors and the highest motor efficiency may not result in satisfactory performance of the vehicle.

An active discussion, following Mr. Gruse's paper, was participated in by Mr. McDonald of West Penn Power Co., Mr. Chandless of General Motors Truck Co., John A. Orr, Equitable Auto Co., Mr. Hoff of Ford Motor Co., Mr. Eaton of Bell Telephone Co., C. R. Noll, Gulf Refining Co., and many others.

Impromptu Meeting Pleases

An impromptu program presented at the Jan. 8 meeting of the Pittsburgh Section proved most enjoyable to an audience of 60 members and friends. The scheduled speaker, A. E. Feragen, Bendix Products Corp., who was to talk on "Steering Problems", was unable to reach Pittsburgh due to the interruption of airplane service from New York.

"Pinch hitting" for Mr. Feragen, John M. Orr, manager, the Equitable Auto Co., presented a paper entitled "Procurement of Materials", C. R. Noll, Gulf Refining Co., made a most illuminating talk on "Oil", and Mr. Chandless and Mr. Fahnestock discussed new features in the 1935 motor car models.

Mr. Orr's paper, previously presented before the Association of Transit Engineers, dealt with problems confronting fleet operators in the procurement, stocking and handling of the materials, parts, and supplies incident to fleet maintenance. Appreciable savings may be made by reducing the amount of "red tape" involved in securing material requisitions for small parts and supplies, without loss of accuracy in stock control, said Mr. Orr. Proper consideration of availability of materials in given localities, stocks carried by convenient jobbers, parts available at local manufacturers branches, etc., will largely eliminate obsolescence and the carrying of cumbersome and expensive inventories. These and other economies which can be made along these lines are very effective in the reductions of maintenance costs which are required in present-day fleet operations.

Mr. Noll, in discussing "Oil", took up in some detail some of the chief problems to be considered by the Society's Lubricants Committee at the Annual Meeting in Detroit. According to Mr. Noll, no satisfactory machine or method for rating extreme-pressure gear lubricants has as yet been adopted. The necessity

of rating such lubricants is becoming increasingly important due to the vast increases in loads to be carried by motor car gears. Higher speeds, smaller gears, and changes in gear design have all contributed to the constantly increasing pressures which the lubricant must withstand. "There are three major requirements to be met by the successful 'EP' lubricant", said Mr. Noll, "first, it must not be corrosive; second, it must not be abrasive; third, it must retain its extreme-pressure characteristics".

Two other problems to be considered are the advisability of changing the viscosity limit of 40 S.A.E. grade oil; and improvement in specifications for transmission and differential lubricants.

Mr. Noll explained the value and use of the "Viscosity Index" in expressing relative heat break down characteristics of lubricating oils.

A lively discussion followed Mr. Noll's talk, "Oil" as usual being a more or less controversial subject.

Three of the speakers on this impromptu program, Mr. Orr, Mr. Noll, and Mr. Fahnestock, are former chairmen of the Pittsburgh Section. Suggestions were made by several present that "impromptu" informal meetings be held more often.

Fischer Speaks On Diesel Applications

• Chicago

The speaker at the Dec. 5 meeting of the Chicago Section, held at the Stevens Hotel, was Hans Fischer, of the Buda Co., whose subject was Diesel Engine Application to Trucks, Tractors and Buses. The total attendance was 119. Prominent discussers were: A. J. Scaife, of the White Co.; A. W. Scarratt, of the International Harvester Co.; and Carl C. Hinkley, of the Buda Co. The meeting was held in connection with a session of the National Tractor and Industrial Power Equipment Meeting of the Society.

Chairman Wilkin presided. He spoke briefly and than introduced Past-Chairman of the Section Harold Nutt, who emphasized the desirability of active interest in the Society's activities by all members.

John A. C. Warner, General Manager of the Society, spoke briefly, and then introduced the speaker, Mr. Fischer.

Carl C. Hinkley stressed the desirability of standardization of Diesel-fuel specifications by the oil companies as a necessary preliminary to the design of Diesel engine satisfactory for transport service.

Father and Son Tell Of Rail-Car Design

• Dayton

A father and son (A. H. and J. C. Fetters) drew a crowd of 350 members and guests to the Dayton Section Meeting on Jan. 17 to hear about the new streamlined, Diesel-powered rail trains.

The elder Fetters (A.H.) is general mechanical engineer of the Union Pacific Railroad, which has one such train in operation and several on order, while the younger Fetters is assistant head, Diesel section, General Motors Research Laboratories, which had considerable to do with "Development of the Winton Diesel Engines Used in the Union Pacific Streamlined Trains."

Dimensional Control Is Fuller's Subject

• Washington

Fundamentals of Mechanical Dimensional Control was the subject of the paper presented by Irvin H. Fullmer, assistant chief of the gage section, National Bureau of Standards, at the joint meeting of the Washington Sections of the American Society of Mechanical Engineers and of the Society, held Jan. 10. The dinner attendance was 20; and 85 were present at the technical session, which was in the auditorium of the Potomac Electric Power Co. The second paper, Engineering Features of 1935 Automobiles, was by Clarence S. Bruce, assistant mechanical engineer, automotive section, National Bureau of Standards.

Mr. Fullmer told of his work in testing and designing precision gages used for controlling dimensions of machine parts, and the current application of optical methods by means of which it is possible to determine lengths to one-millionth of an inch.

Mr. Bruce discussed the engineering features of the cars shown at the New York Show, stressing the improvements in brakes; the economic value of the overdrive transmission; the recent trend to the use of the 16-in. auto wheel with accompanying possibilities of lower tire costs due to fewer sizes to be held in stock; the increase in horsepower of engines due to improved compression ratios and better aspiration of fuel; the recent use of cast iron in high-compression cylinders; the Fisher body turret tops; several methods of individual front-wheel suspension; and other points.

Winkler Presents Induction Data

• Milwaukee

One of the largest meetings of the season in the Milwaukee Section was the postponed December meeting held at the Milwaukee Athletic Club on Dec. 12 last. It was preceded by a dinner to which 62 members sat down, and before the technical session which followed the dinner was started, the audience had doubled in size.

The entertainment feature furnished by the Ford Motor Co. was a rare treat. The talkie film, "A Rhapsody in Steel", showed with magnificent photography the most spectacular manufacturing features at the Dearborn plant; then by very clever animation, the approximate sequence in the assembly of a Ford car and its parts. The picture lasted three-quarters of an hour.

At the conclusion of the film, Chairman Frudden introduced A. E. Winkler, chief engineer, Schwitzer-Cummins Co., who presented an illustrated talk on "Forced Induction", and showed in a graphic manner the improvement in performance that had resulted in the Graham-Paige engine. He took his audience, step by step, through the development of the various types of blowers used, and made the statement that every speed record on land, sea, or air was made by a supercharged engine. Gar Wood's water record of 124.86 m.p.h. was made by a Packard engine that was originally designed for 750 hp., and from which, by supercharging and other refinements, more than 1800 hp. was obtained.

The discussion was centered upon some of the practical aspects such as effect of back-fire, dirt in the intake air, and engine operation in case of drive failure on the supercharger. Mr. Winkler stated that in the case of backfire, owing to the speed of flame travel with relation to the speed of the rotor in the supercharger, the rotor might be considered as stationary because of the high velocity of the flame and, of course, under these conditions, no damage would be expected.

Probably of more practical importance to the operator was the question of engine operation in the case of the supercharger drive failing. He stated that practical experience in this respect showed that while, of course, no supercharging effect took place and the high power and top speeds could not be obtained, operation in the lower speed ranges was very little different, and probably would be unnoticed by the average driver. One of the important points that seemed contrary to popular expectation was that due to the high specific performance of the engine, fuel economy with superchargers had proved to be definitely better.

The unusually long and lively discussion testified to the interest in supercharging.

Aluminum Alloys Presented by Dix

• Buffalo

At the meeting of the Buffalo Section held Dec. 18, at the Hotel Statler, 30 members attended the dinner and 80 were present at the technical session. A paper entitled "New Aluminum Alloys—The Result of Depression Research", was presented by E. H. Dix, Jr., chief metallurgist of the Aluminum Co. of America Research Laboratories. A lengthy discussion was entered into after the presentation, and that considerable interest was manifested is indicated by the large attendance from the local aviation companies.

The trend of Mr. Dix's paper is indicated by the following: The lean years since early 1930 have been productive of more new aluminum alloys than any previous period. Fortunately, a far-sighted management has permitted aluminum research to continue through these depression years at an only slightly reduced rate. Further, because of the demand for ringing the cash register during these years the direction of alloy development has been more carefully controlled in an attempt to develop alloys to meet specific requirements where a tonnage field is indicated. This is really particularly fortunate because it means that the new alloys which have been put on the market are there because of a real need, not merely because of a laboratory discovery.

It is obviously undesirable from many angles greatly to increase the number of alloys. It places an unnecessary burden on the manufacturer which eventually must be reflected as an increased cost and it makes it more difficult for the consumer to make a proper selection. Even now there is a bewildering list of alloy numbers which must be very confusing to the user. The net result of this is that, as new alloys are put on the market, the older less desirable alloys, which they replace, must be removed; but this is not easy to do because a consumer, once having become familiar with the characteristics of an alloy, does not like to change if the alloy is doing the job required of it with reasonable success.

This means that the manufacturer, once having put a number of new alloys on the market, must depend upon the consumer to aid in the elimination of the unnecessary ones. This can only be accomplished by conveying to the consumer the advantages of the newer materials for their applications.

Mr. Dix pointed out the gradual but definite increase in the use of Alclad strong alloy sheet for aircraft and emphasized its high corrosion resistance by recalling the ZMC2 metalclad dirigible of the Navy in which the gas-containing hull is made of Alclad 17S-T sheet 0.0095 in. thick which, after five years' service, has not suffered deterioration by corrosion. The original Alclad material has been followed by Alclad 24S in T and RT tempers, having alloy cores of sufficiently high strength to more than overcome the reduction in strength caused by the thin pure-aluminum coating. The Alclad strong aluminum alloys are proving particularly desirable for spot and seam-welded structures which are being considered by many manufacturers.

Student Activity In Detroit Area

On Dec. 18 an inspection trip was conducted by the Kelvinator Corp. through its plant on Plymouth Road, Detroit, for 150 engineering students from the colleges and universities in the Detroit area. The inspection trip at 1:30 P. M. was followed by three lectures whose purpose was to give up to date information on the engineering principles involved in air conditioning.

The speakers and their subjects were as follows:

1. Dr. C. L. Toonder—Engineering Aspects of Air Conditioning
2. Dr. B. F. Tiffany—Chemistry of Refrigerants
3. Mr. Charles C. Thomas—Design and Construction of the Kelvinator Cabinet

Addition to C-24 Proposed

At the business session of the 1935 Annual Meeting, the following addition to Paragraph 24 of the Constitution of the Society was submitted by J. H. Hunt for the Constitution Committee:

> *"C-24A. Past presidents of the Society shall be admitted to Life Membership without payment of a life membership fee at the end of their second year's service on the Council as Past Presidents."*

This proposed addition will be brought before the business session of the Semi-Annual Meeting at White Sulphur Springs next June for final discussion and amendment before submission to the membership in accord with provisions of the Constitution.

C. F. R. Road Tests

THE C.F.R. Road-Test Method, adopted by the Cooperative Fuel Research Committee in 1932 (see S.A.E. JOURNAL, Vol. 32, No. 3, p. 120) was used as the basic procedure in conducting the 1934 C.F.R. Detonation Road-Tests at Uniontown.

The identity of the branded fuels was concealed throughout the tests. The identity of the non-branded fuels was revealed at the completion of specific portions of the program, but the fuels were re-coded for the remainder of the tests.

Since this "blind" method proved highly satisfactory, suitable changes in the C.F.R. Road Test Method have been authorized by the Committee to provide definitely for such procedure.

Meetings Calendar

S.A.E. Summer Meeting
The Greenbrier, White Sulphur Springs, W. Va., June 16-20, inclusive.

Baltimore—Feb. 7
Engineers' Club of Baltimore; dinner 6:30 P. M. How to Cut Maintenance Costs—A. F. MacDonald, operating manager, Blue Ridge Transportation Co. Discussion by operators of the Blue Ridge Lines.

Buffalo—Feb. 12
Hotel Statler; dinner 6:30 P.M. Oiliness—Dr. A. W. Burwell.

Canadian—Feb. 20
Royal York Hotel, Toronto; dinner 7:00 P. M. Merits and Demerits of Car Design Revisions as Seen by Service Managers—Charles Feaver and H. S. D. Woolley.

Cleveland—Feb. 11
Cleveland Club; dinner at 6:30 P. M. Speaker—Arthur Nutt, vice-president in charge of engineering, Wright Aeronautical Corp.

Dayton—Feb. 12
Engineers' Club; dinner 6:30 P. M. Sheet Metal Blanking and Deep Drawing Dies and Their Correlation—E. V. Crane, E. W. Bliss Co.

Indiana—Feb. 14
The Athenaeum, Indianapolis; dinner 6:30 P. M. Review of Shows.

Kansas City—Feb. 8
Social Meeting.

Metropolitan—Feb. 11
Roger Smith Hotel, New York; dinner 6:30 P. M. Railcars—E. R. Gurney.

Milwaukee—Feb. 6
Milwaukee Athletic Club; dinner 6:45 P. M. Ladies' Night; address—"Art in Industry," by Gustav Boerge Jensen, artist.

New England—Feb. 12
Walker Memorial, Massachusetts Institute of Technology, Cambridge; dinner 6:30 P. M.

Northern California—Feb. 12
Oakland, California. Safety—Dr. F. C. Stanley, chief engineer, Raybestos-Manhattan, Inc.

Northwest—Feb. 8
New Washington Hotel, Seattle; dinner 6:30 P. M.

Oregon—Feb. 8
Lloyd's Club House, Portland; dinner 6:30 P.M. Report of Annual Meeting of the Society—Chairman H. W. Drake.

Philadelphia—Feb. 13
Philadelphia Automobile Trades Association, Inquirer Bldg.; dinner 6:30 P. M. 1935 Show Cars—Herbert Chase.

Pittsburgh—Feb. 5
Pittsburgh Athletic Association; dinner 6:30 P. M.

Syracuse—Feb. 4
Onondaga Hotel; dinner 6:30 P. M. Latest Motor Developments—E. R. Jacoby, chief engineer, Continental Motors Corp.

Washington—Feb. 4
University Club, Washington, D. C.; dinner 6:30 P. M. Speaker—Starr Truscott, of the National Advisory Committee for Aeronautics.

Reports of Committees

Meetings Committee Report

THE Meetings Committee with the cooperation of the Professional Activities has sponsored six meetings during the present administrative year, the period extending from the close of the 1934 Annual Meeting to the close of the 1935 Annual Meeting. These six general meetings (as distinguished from sectional and regional meetings) are as follows:

Meeting	Place	Date	No. of Sessions	No. of Papers	Attendance
Tractor	Chicago	April 18 & 19	5	6	200
Summer	Saranac Inn, N. Y.	June 17-22	18	32	549
Production	Detroit	Oct. 10 & 11	4	5	158
Tractor	Chicago	Dec. 5 & 6	5	6	
Annual Dinner	New York	Jan. 7	1	1	
Annual	Detroit	Jan. 14-18	16	38	

S.A.E. Engineering Exhibit—Detroit—Jan. 14-18

In the case of the Annual Dinner, Annual Meeting and Summer Meeting, the Meetings Committee is in charge of arrangements and receives the cooperation of the various Professional Activities in the preparation of the technical programs. Meetings other than the three just mentioned are handled by the respective Professional Activities that sponsor them.

Because of the interest and enthusiasm shown with respect to the Engineering Display, which was inaugurated at the International Automotive Engineering Congress in 1933 and repeated at the 1934 Annual Meeting, the Meetings Committee decided to hold a similar exhibition at the 1935 Annual Meeting. With thirty-three exhibitors taking part in the Display, this exhibition, meeting the need of various companies to display their products and to spread technical information to the engineers attending the sessions, was an attractive feature of the 1935 Annual Meeting as it was at the two earlier meetings at which a similar display was staged.

Besides sponsoring the general meetings mentioned above, the Meetings Committee has been very much interested in the holding of regional meetings and has encouraged the staging of such meetings, as reported under Section Activities.

As 1935 marks the 30th Anniversary of the founding of the Society, the Meetings Committee believes that all meetings to be held during the year should carry the 30th Anniversary spirit, starting with the 1935 Annual Dinner.

The Meetings Committee wishes to express its appreciation to the Chicago Section, the Detroit Section and the Metropolitan Section for cooperating so effectively with the Meetings Committee in connection with the general meetings held in their respective localities.

—ALEX TAUB, *Chairman*

Membership Commitee Report

THE activity of the Membership Committee is shown by a sizable increase in number of applications for membership over those received during the same period last year. Noticeable, too, is the fact that the greater number of applicants for membership have qualified promptly by payment of their initiation fee and dues.

Number of applications received as of Dec. 31, 1934—431
Enrolled Students—225
Number of applications received as of Dec. 29, 1933—321
Enrolled Students—169

During the month of November, 1934, 50 applications for membership were received, and during December, 44 were received, which would indicate a general upward trend in the membership curve.

The Membership Committees of the Sections have cooperated actively in the general membership endeavors.

The following membership statistics are presented to show the details for 1934 as well as the comparative figures for 1933:

	1934 (as of Dec. 31)	1933 (as of Dec. 29)
Members	2,643	2,481
Associates	1,280	1,214
Juniors	315	338
Foreign Members	311	288
Service Members	78	94
Departmental Members	2	2
Affiliate Members	78	81
Affiliate Member Representatives	130	132
Enrolled Students	194	216
	5,031	4,846

In the 1933 period, some 2240 reserve members were carried, whereas in 1934 the figure was reduced to 585.

A definite improved trend is shown in our membership, and particularly in the number of applications received during the past few months.

The Committee wishes to express its sincere appreciation to the members of the Sections who have worked so diligently throughout the year in the membership endeavors of the Society.

—F. K. GLYNN, *Chairman*

Publication Committee Report

WITH the cooperation of special committees of volunteer readers representing each of the activities of the Society, the Publication Committee during the past year has maintained a high quality in the papers selected for publication definitely chosen by these committees of experts as worthy of publication.

During the calendar year of 1934, 741 pages of text and 460 pages of revenue advertising were published in the JOURNAL. Of the text pages, 541 or approximately 73 per cent consisted of papers and discussion; 466 of these pages were published in the Transactions Section. During the preceding year, 1933, 782 pages of text were published, of which 445 or 56.9 per cent consisted of papers and discussion. In 1933, there were published 343 pages of revenue advertising.

Sixty-one complete papers, some with discussion, and nine discussions printed separately, were published during the year 1934. In addition, there were published three special articles, all of which dealt with technical problems.

In addition, eight pages of the JOURNAL were devoted to printing for purposes of record, brief abstracts of all papers presented at the various general and Section meetings of the Society. This practice was begun immediately following the 1934 Semi-Annual Meeting and is being continued as a regular part of the JOURNAL program. Twelve pages more were devoted to digests in similar form of the oral discussion at the Summer Meeting.

Transactions

Transactions of the Society were brought up to date by publication about the end of February of Volume 28 covering the year 1933. In this volume there were 408 pages. It contained 54 papers and 5 discussions printed separately.

Volume 28 was sold to members for $2, the charge being entered upon the bill for annual dues.

S.A.E. Handbook

The August 1934 Supplement to the 1933 S.A.E. HANDBOOK was issued to bring the published S.A.E. specifications up to date through the Semi-Annual Meeting in June, 1934. This Supplement includes all of the new and revised specifications that were adopted by the Society, and noted one that was cancelled. Plans are under way for issuing a new complete edition of the HANDBOOK in 1935 and all of the specifications in the Supplement will be included in this new edition.

Roster

The S.A.E. ROSTER for 1934 contained 32 fewer pages than the 1933 ROSTER, this saving being effected by omitting the names of members on our Reserve Membership List. All the other information contained in the ROSTER for last year was retained.

The ROSTER for 1935 will be issued about the middle of February and will be similar in all respects to last year's book.

—JOHN H. HUNT, *Chairman*

Research Committee Report

IN addition to the normal, expected progress on the various research projects sponsored by the Society during 1934, the research activity has taken two notable forward steps in the organization of a Research Executive Committee and the formulation of a definite statement of regulations for the guidance of research activities.

The Research Executive Committee, in addition to other duties designated by the Research Committee Regulations, acts in an advisory capacity to the Research Committee and as an alternate to it on some subjects as delegated by the Research Committee, its actions being subject to review by the Research Committee.

The Executive Committee is composed of the chairmen of the research subcommittees under the chairmanship of the Chairman of the Research Committee and, therefore, it is to be expected that its personnel will always be comparatively small. It is hoped that this new organization plan will provide means whereby details in connection with the direction and management of the Society's Research work can be executed more expeditiously and effectively.

Crankcase Oil Stability

A year ago a special committee was delegated by the Crankcase Oil Stability Research Committee to obtain from the automotive industry an unbiased appraisal of this problem. Toward this end the members of this small committee canvassed both personally and by mail more than a hundred equipment and lubricant manufacturers and commercial operators. The results of this survey indicated that a majority is of the definite opinion that the problem is one requiring immediate attention, particularly from the point of view of development of necessary facilities for evaluating oils from the point of view of tendencies to crankcase sludge formation, ring sticking, acidity and viscosity increase. Accordingly it was recommended that the Society's Crankcase Oil Stability Subcommittee continue the investigation of the problem, particularly from the service aspect, in order to supplement further the information already obtained on the effects of oxidation of lubricating oils and the variation of these effects with different oils and with different conditions of service.

A tentative program is being formulated for consideration at the next meeting.

Extreme-Pressure Lubricants Research

Following the development, at the Bureau of Standards under the sponsorship of the Subcommittee, of a research machine for testing the load-carrying capacity of extreme-pressure lubricants, cost estimates were obtained. Because of the costliness of this machine several members of the Committee, authorized by the Executive Committee of the E-P Lubricants Subcommittee, cooperated with the Chairman in the construction of a small machine with fewer controllable variables which it was expected could be built at a lower cost. Under the immediate direction of W. S. James, Chairman of the Committee, the small machine was designed, and constructed in the shops of the Studebaker Corp., cost estimates were obtained, and a series of tests run at the laboratories of the Studebaker Corp., Standard Oil Co. of Indiana, General Motors Corp., and the Standard Oil Development Co. At each of these laboratories members of the Committee conveniently located were invited to inspect the machine and witness tests. Results obtained in these tests were reported to the Committee and while they were considered sufficiently encouraging to justify further development of the machine, a number of changes were considered desirable before additional machines were made available to members of the Committee who may wish to participate in a cooperative program of load-carrying capacity tests which is being formulated by a special subcommittee. In cooperation with other members of the Extreme-Pressure Lubricants Research Subcommittee, and particularly with the executive group, T. C. Smith, Chairman of the Operators Division of the Committee, prepared a design covering the latest ideas in an extreme-pressure lubricants testing machine. Upon completion of the drawings, cost estimates were obtained and the first machine completed for exhibition at the Society's Annual Meeting. The Committee hopes that a limited number of these machines will be available early in 1935 and present information indicates that the approximate cost of the machine will be between three and four hundred dollars.

Front Wheel Alignment

A proposed code of basic instructions for wheel alignment of motor vehicles has been formulated by the Front Wheel Alignment Research Subcommittee, discussed, revised in accordance with suggestions and is now being considered by the Committee in revised form.

Highways Research

The Highways Research Subcommittee has continued its cooperation with the research staff of the Federal Coordinator of Transportation in providing what information it had available as an aid in formulating a policy of highway utilization.

Another phase of the Highways Subcommittee's work has been concerned with turning direction signals. Written comments were submitted to the Lighting Division of the Standards Committee on a set of specifications prepared by the Division for testing turning direction signals of the electrical type. A statement of the viewpoint of the Highways Research Subcommittee on the turning direction indicator problem has been prepared, but the Committee is not yet in unanimous agreement with regard to it, and is giving the subject further study.

Ignition Research

During the latter part of 1933 the Society undertook joint sponsorship with the Bureau of Aeronautics, Navy Department, of a research investigation of aviation spark plugs being carried out at the National Bureau of Standards with funds provided by the AC Spark Plug Co.

The work covered thus far has included the testing of mica spark plugs, submitted by the leading makers of aviation plugs, as to fouling and preignition characteristics and the study of heat transfer between the shell and center electrode.

Consideration has been given to the extension of this investigation to other types of spark plugs and the development of some standard method of specifying the relative coldness of spark plugs.

Following the instructions of the Research Committee at its meeting in January, 1934, an Ignition Research Subcommittee has been organized, headed by A. L. Beall, Wright Aeronautical Corp., to assist in an advisory capacity in guiding the project. Two meetings of the Subcommittee have been held and a tentative program for the immediate future adopted, the objective being to establish some standard test for lead deposits.

Riding-Comfort Research

A request for suggestions and opinions from members of the Riding-Comfort Research Subcommittee, and others in the industry interested in this project, as to the most beneficial future activities in the determination of riding-comfort performance of motor vehicles has resulted in extensive returns which are being analyzed and summarized into a proposal for future work to be considered by the Research Committee at its next meeting.

To dispel any ambiguity which may still exist in individual conceptions of the riding comfort problem, Dr. H. C. Dickinson was requested to formulate a fundamental definition of the measurement problem. Such a definition entitled, "Analysis of Riding-Comfort Factor" is being circulated for comments.

Cooperative Fuel Research

In the field of fuels research the Society has continued its sponsorship jointly with the American Petroleum Institute, the Automobile Manufacturers Association and the National Bureau of Standards in the Cooperative Fuel Research. During the past year the work of that Committee has been concerned chiefly with detonation of motor and aviation gasoline.

The 1934 C.F.R. detonation road tests, conducted at Uniontown during the past summer, had the twofold purpose (a) to check the validity of correlation between road knock ratings and laboratory knock ratings; and (b) to indicate promising paths of research directed toward better mutual adaptation of fuels and engines. The results of this work are covered in detail in a report of the Cooperative Fuel Research Committee presented at the Society's 1935 Annual Meeting.

The Aviation Gasoline Detonation project has proceeded, along the lines laid out in the original program adopted early in 1933, to a point near completion. Two reports covering this work have been presented to the Society during the past year by Chairman Arthur Nutt: (a) "Correlation of Knock Ratings of Aviation Gasolines", at the Summer Meeting at Saranac Inn and (b) a progress report of the C.F.R. Aviation Gasoline Detonation Subcommittee, at the Annual Meeting.

The paper, "Fuel Characteristics and Vapor Lock" presented by Dr. O. C. Bridgeman at the Society's Summer Meeting, constitutes the most recent report on that subject and no further work on vapor lock is in progress at present under the direction of the C.F.R. Committee.

—R. R. TEETOR, *Chairman*

Sections Committee Report

WITH a total of 166 meetings, at which there was an attendance of about 19,000, the Sections wound up the calendar year with a fine set of meetings in December. This represents an increase over the same period last year, during which time 159 Section meetings were held. With attendance curves on the upgrade, and with the live Section organizations now actively in operation, indications are that the increase in number of meetings and in attendance will be maintained, and in all probability substantially surpassed.

The 166 Section meetings held from January to December, 1934, contained papers on subjects as listed below:

Aeronautics	15
Bodies	23
Diesel Engines	3
Engines	10
Fuels and Lubricants	15
General	33
Iron and Steel	1
Ladies' Nights	8
Marine	3
Materials	3
Parts and Equipment	6
Passenger Car	22
Production	2
Research	4
Rubber Products, Tires	4
Transportation and Maintenance	7
Traffic and Safety	4
Trucks, Buses and Railcars	10
Welding	2

The general meetings were on such topics as racing car developments, legislative problems, technical education, technical uses of motion pictures, etc., as well as some meetings devoted to plant inspections.

The number of regular and probationary Sections remains the same, there being 20 regularly constituted Sections and two probationary groups—Kansas City and St. Louis.

In accordance with the plan inaugurated the early part of the year, the Sections have been encouraged to stage Regional Meetings in outlying districts of their territories for the benefit of those members who ordinarily do not have the opportunity of attending the regular meetings of the Section because of the distance involved. Five such Regional Meetings have been sponsored by the Sections with very gratifying results: Dayton Section in Hamilton, Ohio; Milwaukee Section in Waukesha, Wis.; Chicago Section in South Bend, Ind.; Metropolitan Section in Newark, N. J.; and Indiana Section in Lafayette, Ind. The Metropolitan and New England Sections were co-sponsors with the Society in a highly successful Regional Meeting held on Dec. 14 in Hartford, Conn. The Sections are being encouraged to continue this practice of holding Regional Meetings, and indications are that their activities will be spread over their territories in neighboring cities, instead of concentration in one city as heretofore.

The S.A.E. Club of Denver started activities for the season with a meeting on Nov. 13, according to information received from Elmer J. Graham, who has been active in the Club since its inauguration. The meetings of the Club have provided the means of holding together on common ground the S.A.E. members in the vicinity of Denver, and Dean M. Gillespie has been elected President of the group for the year.

Student Activities

Student activities of the Society got under way with the opening of the Fall semester and the election of officers of the five Student Branches of the S.A.E. in the following universities: General Motors Institute of Technology, Massachusetts Institute of Technology, Ohio State University, New York University, and the University of Detroit.

Eight Sections of the Society have undertaken cooperative relations with the students in universities and colleges in their territories, maintaining them on their mailing lists to receive all Section literature and invitations to Section meetings. Noticeable among these are the Detroit, Metropolitan, New England and Oregon Sections, where interesting results have been accomplished. The Oregon Section has carried on vigorously in cooperation with Oregon State College, where students tend toward the formation of a Student Branch of the S.A.E. in that university. This matter has been placed before the Special Student Activities Committee. A special course of study on lubrication problems was sponsored very successfully by the Cleveland Section in cooperation with the Case School of Applied Science.

Membership Work in the Sections

Most of the Sections have energetic plans under way, in cooperation with the General Membership Committee of the Society, in a concerted effort to retrieve as many of the delinquent and reserve members as possible, and to obtain new and live prospects for membership, which will be mutually beneficial to the Sections and the Society.

Placement Work in the Sections

Section cooperation in this important work has been very gratifying. The plan of breaking down the Men Available list according to Sections, and forwarding these names to the Sections, has met with almost general approval among the Sections, and most of them have agreed to assist as much as possible in aiding their local members to obtain employment. Eleven Sections have appointed members to head up this work in the Section, and to cooperate with the Placement Service at Headquarters. Men Available and Position Available Bulletins are sent regularly to these men as issued, and any assistance desired by them rendered by the Placement Department.

Headquarters office has devised a means of keeping the Sections in closer contact with what is going on in the national organization through a "Section-Gram" which is sent out periodically and contains items of interest to the Sections and various helps as they are encountered.

On the whole, the Sections have maintained a healthy pace during the past year. Much credit is due to the energetic work of the Section officers, which has been agreeably reflected in the interest and activity of the membership of the various Sections. The outlook for the coming year, as based on the progress realized last year, is an optimistic one.

—Harold Nutt, *Chairman*

Standards Committee Report

At the close of this administrative year, it can be reported that the Standards Committee has made unusual progress on a number of major standardization projects.

Division Reports

Up to the time of preparing this report, recommendations by five Divisions had been approved and adopted by the Society since the Annual Meeting last January. These embraced completely revised specifications for motor vehicle storage batteries, including the addition of notes on testing storage batteries, submitted by the Electrical Equipment Division. The Aircraft Division reported revised standards for flat head pins and aircraft bolts and nuts. The Iron and Steel Division reported a series of charts to be used for classifying S.A.E. and allied structural steels according to grain size, that are in accord with the corresponding specification of the American Society for Testing Materials. As a result of over two years of work, the Lighting Division submitted reports on revised laboratory tests for electric headlamps and for reflex reflectors for motor vehicles and a new recommended practice for headlight switching. The Transportation Division submitted a completed Uniform Motor Vehicle Operating Cost Classification that includes three groupings of the classification items, one group appropriate for use by small motor vehicle fleet operators, one for moderate sized operators and a more comprehensive one for the larger fleet operators. The extended general classification includes also the cost record forms that are necessary for each of the group divisions.

At the time of preparing this report, a number of important projects were nearing completion for submission to the general Standards Committee and Council for adoption at the Annual Meeting in January. Among the more important of these are a complete review and revision of the S.A.E. Iron and Steel specifications, notes on heat treatments and physical properties. This has been a project of great scope and importance. The Motorboat and Marine Engine Division is expected to submit reports on a standard for mounting outboard motors and also a revised standard for propeller shaft ends and propeller hub bores. The spark-plug specifications have been brought up to date by the Gasoline Engine Division and will include the thread specifications for the 14 mm. spark plug. The Motorcoach and Motor Truck Division is balloting on the adoption of recommended tank dimensions on gasoline tank trucks that were developed in cooperation with Committees of the American Petroleum Institute and the truck tank manufacturers. The Passenger Car Division has been cooperating with a Sectional Committee under the American Standards Association procedure in developing test specifications for the several types of safety glass used in motor vehicles. The Screw Threads Division is reviewing the complete revision and extension of the general standards for screw threads, for approval both as S.A.E. Standard and as American Standard.

Under the Passenger Car Division, work has also continued in cooperation with the Automobile Radio Committee of the Radio Manufacturers Association which includes the program of investigation of the phenomena of interference by automobile ignition systems.

Sectional Committees

Many of the projects in Sectional Committees for which the Society is sponsor or on which it is represented, are of necessity long-time undertakings. Progress on a number of these has been made during the year, notably in the fields of small tools, screw threads and threaded products. Among the more important projects are also the development of standard test methods for safety glass, referred to above, and the further development of a code or classification for surface finishes on different metallic and non-metallic materials used in industrial manufacture. As these and other projects near completion in Sectional Committees they will be reported on from time to time in the S.A.E. Journal or referred to the industry by correspondence.

International Standardization

There is relatively little to report this year in this field of the Society's activities except that in the field of automobile tires, the Society has cooperated with the Tire and Rim Association, Inc., in working towards international agreement on tire sizes, with the assistance of the American Standards Association. It appears probable that only limited results should be expected in this direction due to the varying conditions and requirements in different countries, especially those on the Continent. A number of European international groups organized and functioning under the International Standards Association of which the A.S.A. is a member, held a series of conferences this fall on a number of automotive topics but information regarding the results of these conferences is not yet available. Participation in these international activities will be continued where feasible and practical results can be had.

General Activities

As in previous years the Society has continued its cooperative activities with other groups such as the Army-Navy Standards Conferences, the American Society for Testing Materials, the American Petroleum Institute, the Radio Manufacturers Association and others whose activities reach into the automotive industry.

S.A.E. Handbook

Efforts have been continued to build up the S.A.E. HANDBOOK into a better and more up to date reference publication. The 1933 edition and the August 1934 Supplement to it were widely distributed to other engineering societies, associations, colleges, libraries, state regulatory officials, etc., here and to many groups abroad, including practically all industrial countries of the world.

The August 1934 Supplement was issued last August and included all of the new and revised standards that were adopted by the Society at the Annual Meeting last January and the Semi-Annual Meeting in June.

Preparations are being made to issue a new complete edition of the S.A.E. HANDBOOK as soon as possible which will place in the hands of the members and others to whom the HANDBOOK is sent the complete S.A.E. Standards, brought up to date so far as possible, including those that were published in the August 1934 Supplement.

It is interesting to note that during each year a large quantity of complete HANDBOOKS as well as individual standards are furnished on request to a large variety of industrial companies producing or handling other than automotive products. Material specifications such as the steels and non-ferrous metals have a particularly wide distribution and application.

General Recommendations

It is apparent that the automotive and associated industries are emerging from the conditions of the past few years with the development of many new ideas and products. There is a growing recognition of the importance and value of practical engineering standardization in the design and manufacture of engineered products and your Committee strongly recommends that the work of the Society in this field be given even greater recognition and support by the industry through the men on the various Divisions of the Standards Committee who are carrying this work forward and by a wider application and use of the results of their efforts.

—C. W. SPICER, *Chairman*

Treasurer's Report

WHILE your Finance Committee recommended a deficit of $14,480 for the fiscal year ending Sept. 30, 1934, it is a pleasure to report that the deficit at that date was but $3,484.07, due to improved revenue and to careful management, and without reducing any service to the members of the Society.

For the fiscal year the operating deficit was $185.07. The total deficit of $3,484.07 included a loss on the sale of securities of $3,299. Securities that cost the Society $10,670 were sold for $7,371, and represented the weakest holding in our security portfolio, and the sale was recommended by the Bankers Trust Co., custodian, as a step in strengthening our security holdings.

The investment portfolio of the Society is carried at a book value of $161,904.50 and their market value at the close of the fiscal year showed that they were 2 per cent under their purchase price.

The year's income increased $13,579.27 over the budget estimate, due to a general increase in all such sources of revenue as JOURNAL advertising, members' dues, initiation fees and miscellaneous sales. Income was 6 per cent over that of the previous fiscal year. During the year the operating expenses were $715.66 below that fixed by the budget. They were 5½ per cent under the operating expenses of the previous year.

The comparative balance sheet and the income and expense statement as of Sept. 30, 1934, which are a part of this report, show in detail the status as of that date.

—DAVID BEECROFT, *Treasurer*

COMPARATIVE BALANCE SHEET AS OF SEPT. 30, 1933, AND SEPT. 30, 1934

Assets	1933-4	1932-3
Cash	$ 29,949.39	$ 14,093.13
Accounts Receivable	4,788.56	9,045.34
Securities	*161,904.50	172,574.50
Accrued Interest on Securities	2,586.67	2,784.58
Inventories	798.55	757.40
Furniture and Fixtures	1,000.00	1,000.00
Items Paid in Advance, Charges Deferred	3,605.46	4,205.62
TOTAL ASSETS	$204,633.13	$204,460.57
Liabilities and Reserves		
Accounts Payable	$ 2,622.87	$ 14,300.92
National Dues and Miscel. Items Received in Advance	14,665.62	3,923.24
Reserves Set Aside for Anticipated Expenses	4,462.11	1,869.81
General Reserve	184,366.60	207,320.64
Adjustment to General Reserve	2,000.00	....
Net Unexpended Income	185.07[a]	22,180.34[a]
Loss from Sales of Securities	3,299.00	773.70
TOTAL LIABILITIES AND RESERVES	$204,633.13	$204,460.57

* Book Value (Market Value, Sept. 30, 1934, $158,918.75).
[a] Deficit.

INCOME AND EXPENSE AND BUDGET COMPARISON
TWELVE MONTHS, ENDING SEPTEMBER 30, 1934

Income	Oct. 1 to Sept. 30 1933-4	Oct. 1 to Sept. 30 1932-3	Budget
Dues and Subscriptions	$ 67,755.80	$ 69,061.75	$ 65,000.00
Initiation Fees	6,025.00	6,395.00	5,500.00
Interest and Discount	7,823.59	9,067.70	8,000.00
Affiliated Appropriations	416.66	....	....
Advertising Sales—Journal	85,135.00	70,805.00	80,000.00
Advertising Sales—Handbook	1,950 00	3,500.00	....
Miscellaneous Sales	16,198.22	15,101.49	14,000.00
Unused Portion of Section Dues	775.00	1,251.50	....
TOTAL INCOME	$186,079.27	$175,182.44	$172,500.00
Expense			
Research	$ 15,099.65	$ 12,518.77	$ 14,330.00
Standards	7,601.60	6,995.90	7,140.00
Publications	37,170.95	46,279.28	38,270.00
Sections	4,102.96	4,945.51	5,205.00
Meetings	9,772.67	14,173.14	12,610.00
Professional Activities	227.86	132.90	200.00
Cost of Membership Increase	8,555.14	8,809.85	7,920.00
Cost of Advertising Sales—Journal	26,344.06	25,330.31	24,760.00
Cost of Advertising Sales—Handbook	330.38	758.10	....
Cost of Miscellaneous Sales	5,618 20	6,324.66	6,370.00
General Expense	71,440.87	71,094.36	70,175.00
TOTAL EXPENSE	$186,264.34	$197,362.78	$186,980.00
Net Unexpended Income	185.07[a]	22,180.34[a]	14,480.00[a]
Loss from Sales of Securities	3,299.00	773.70	....

[a] Deficit.

Personnel of 1935 S.A.E. Committees

PRESIDENT WILLIAM B. STOUT announces the following appointments on the Administrative Committees of the Society and the personnel of the Professional Activities, Technical and Special Committees for 1935.

These include the Research Committee and its Subcommittees, the Standards Committee and its Divisions, the Society's Special Committees and Cooperative Committees on which the Society is represented with other organizations. Acceptance of their appointment has been received from virtually all of those named.

Administrative Committees

CONSTITUTION COMMITTEE

B. B. Bachman—*Chairman* (1 year)	J. H. Hunt (2 years)

W. T. Fishleigh (3 years)

FINANCE COMMITTEE

B. B. Bachman—*Chairman*	H. M. Crane
	C. B. Whittelsey
David Beecroft	R. E. Wilson

HOUSE COMMITTEE

Charles L. Drake—*Chairman*	D. A. Fales
	Grosvenor Hotchkiss
Sherman Bushnell	O. M. Thornton

MEETINGS COMMITTEE

A. L. Beall—*Chairman*	J. B. Macauley—*Vice-Chairman*
Murray Fahnestock	C. G. Krieger

E. C. Wood

PROFESSIONAL ACTIVITIES REPRESENTATIVES

Aircraft	Peter Altman
Aircraft Engine	Robert Insley
Diesel Engine	L. C. Lichty
Fuels & Lubricants	H. F. Huf
Passenger Cars	Alex Taub
Passenger Car Body	F. S. Spring
Production	J. Geschelin
Transportation	F. K. Glynn
Truck, Bus & Railcar	L. R. Buckendale

SECTION REPRESENTATIVES

Baltimore	Wm. H. Beck
Buffalo	T. M. Nevin
Canadian	Max Evans
Chicago	Fred L. Faulkner
Cleveland	J. V. Whitbeck
Dayton	C. S. McCann
Detroit	Vice-Chairman for each Activity
Indiana	Herman Winkler
Kansas City	Morris Cohen
Metropolitan	C. H. Baxley
Milwaukee	Roger Birdsell
New England	S. S. Burgey
No. California	Howard Baxter
Northwest	Murray Aitkin
Oregon	Governing Board
Philadelphia	Donald Blanchard
Pittsburgh	A. L. Hall
St. Louis	John Cox
So. California	F. C. Patton
Syracuse	Charles Logue
Washington	C. S. Bruce

ENGINEERING DISPLAY SUBCOMMITTEE

Alex Taub, *Chairman*

MEMBERSHIP COMMITTEE

W. C. Keys—*Chairman*	Harold Nutt—*Vice-Chairman*
R. H. Combs	W. H. Fairbanks

H. T. Youngren

PROFESSIONAL ACTIVITIES REPRESENTATIVES

Aircraft	J. R. Cautley
Aircraft Engine	R. W. Young
Diesel Engine	Harte Cooke
Fuels & Lubricants	B. E. Sibley
Passenger Car	W. C. Keys
Passenger Car Body	W. A. Houser
Production	R. S. Drummond
Transportation	R. T. Hendrickson
Truck, Bus & Railcar	M. C. Horine

SECTION REPRESENTATIVES

Baltimore	Geo. E. Hull
Buffalo	Earl V. Schaal
Canadian	F. W. Miller
Chicago	A. Vance Howe
Cleveland	Hoy Stevens
Dayton	Z. C. Bradford
Detroit	C. O. Richards
Indiana	Clessie L. Cummins
Kansas City	Wm. B. Wightman
Metropolitan	L. M. Porter
Milwaukee	Geo. W. Curtis
New England	R. W. Barrett
No. California	John Hunsaker
Northwest	W. W. Churchill
Oregon	E. H. Swayze
Philadelphia	A. Gelpke
Pittsburgh	Robert E. Behlen
St. Louis	Geo. C. Stevens
So. California	G. A. Collander
So. California	M. P. Brooks
Syracuse	E. R. Fish
Washington	C. S. Bruce

PUBLICATION COMMITTEE

J. H. Hunt—*Chairman*	G. L. McCain
	P. C. Ritchie
G. W. Lewis	S. W. Sparrow

SECTIONS COMMITTEE

*M. A. Thorne—*Chairman*	*F. K. Glynn—*Vice-Chairman*

*L. P. Saunders

J. A. Anglada (Metropolitan)
A. K. Brumbaugh (Cleveland)
F. C. Buchanan (Kansas City)
W. K. Creson (Indiana)
H. K. Cummings (Washington)
H. W. Drake (Oregon)
C. M. Eason (Milwaukee)
J. S. Erskine (Chicago)
J. C. Geniesse (Philadelphia)
F. W. Heckert (Dayton)
H. F. Hodgkins (Syracuse)
J. G. Holmstrom (Northwest)
C. H. Jacobsen (So. California)
F. E. H. Johnson (New England)
C. F. Lautz (Buffalo)
W. E. McGraw (Canadian)
C. R. Noll (Pittsburgh)
T. B. Rendel (St. Louis)
Mac Short (Wichita)
J. A. White (Baltimore)
E. C. Wood (No. California)
H. T. Woolson (Detroit)

*Members at large.

Professional Activities Committees

AIRCRAFT COMMITTEE

C. H. Chatfield—*Chairman*	K. M. Lane
	J. G. Lee
W. A. Hamilton—*Vice-Chairman*	G. W. Lewis
	L. C. Milburn
Peter Altman	E. G. Reid
F. W. Caldwell	H. J. E. Reid
J. R. Cautley	Mac Short
Robert Craig	I. I. Sikorsky
R. C. Gazley	E. P. Warner
J. C. Hunsaker	Orville Wright
S. J. Zand	T. P. Wright

AIRCRAFT-ENGINE COMMITTEE

P. B. Taylor—*Chairman*	S. D. Heron
	Robert Insley
A. V. D. Willgoos—*Vice-Chairman*	C. L. Lawrance
	G. W. Lewis
Opie Chenoweth	Arthur Nutt
Roland Chilton	C. F. Taylor
H. K. Cummings	R. W. Young

DIESEL ENGINE COMMITTEE

C. L. Cummins—*Chairman*	H. D. Hill
	Carlton Kemper
A. W. Pope, Jr.—*Vice-Chairman*	E. T. Larkin
	L. C. Lichty
E. W. Beach	A. A. Lyman
H. D. Church	J. G. Oetzel
Harte Cooke	W. A. Parrish
John Dickson	W. H. Radford
C. O. Guernsey	Rudolph Schneider
A. S. Hawks	C. F. Taylor
G. W. Hobbs	O. D. Treiber
M. S. Huckle	E. T. Vincent
	H. E. Winkler

FUELS AND LUBRICANTS COMMITTEE

D. P. Barnard—*Chairman*	Graham Edgar
	C. E. Frudden
T. B. Rendel—*Vice-Chairman*	H. F. Huf
	J. B. Macauley
W. G. Ainsley	K. G. Mackenzie
A. E. Becker	F. C. Mock
H. W. Best	Arthur Nutt
T. A. Boyd	A. W. Pope, Jr.
A. L. Clayden	B. E. Sibley
Harte Cooke	J. B. Terry

A. V. D. Willgoos

PASSENGER-CAR COMMITTEE

L. P. Kalb—*Chairman*	G. L. McCain
	E. S. MacPherson
C. R. Paton—*Vice-Chairman*	L. S. Sheldrick
	E. H. Smith
G. C. Brown	S. W. Sparrow
R. E. Cole	Alex Taub
W. C. Keys	J. J. Wharam
F. F. Kishline	K. M. Wise
G. H. Kublin	H. T. Woolson
B. J. Lemon	H. T. Youngren

PASSENGER-CAR BODY COMMITTEE

C. O. Richards—*Chairman*	O. F. Graebner
	W. A. Houser
W. N. Davis—*Vice-Chairman*	J. R. Hughes
	G. J. Monfort
I. L. Carron	A. J. Neerken
Gustave Chutorash	C. B. Parsons
E. C. DeSmet	F. S. Spring
G. O. Goller	R. J. Waterbury

PRODUCTION COMMITTEE

V. P. Rumely—*Chairman*
J. Geschelin—*Vice-Chairman*
H. D. Allee
J. W. Brussell
F. H. Colvin
R. S. Drummond
P. W. Fassler
James Fletcher
Otto Graebner
R. C. Hoffman
W. B. Hurley
W. H. McCoy
W. W. Nichols
J. E. Padgett
E. R. Smith

TRACTOR AND INDUSTRIAL POWER EQUIPMENT COMMITTEE

C. G. Krieger—*Chairman*
A. W. Lavers—*Vice-Chairman*
D. P. Barnard
R. C. Chesnutt
A. T. Colwell
J. M. Davies
P. W. Eells
O. E. Eggen
J. B. Fisher
C. E. Frudden
R. B. Gray
Elmer McCormick
A. F. Milbrath
C. W. Smith
K. D. Smith
L. B. Sperry

TRANSPORTATION AND MAINTENANCE COMMITTEE

(1934 Committee continued pending election of vice-president representing Transportation and Maintenance Activity for 1935)

L. V. Newton—*Chairman*
John Orr—*Vice-Chairman*
W. C. Becker
J. C. Bennett
C. H. Bolin
Clinton Brettell
A. F. Coleman
W. J. Cumming
Henry Dakin
H. W. Drake
F. K. Glynn
H. R. Grigsby
R. T. Hendrickson
H. R. Holder
F. C. Horner
A. A. Lyman
J. G. Moxey
E. S. Pardoe
F. C. Patton
T. L. Preble
A. J. Scaife
T. C. Smith
M. F. Steinberger
E. L. Tirrell
J. F. Winchester
E. C. Wood

TRUCK, BUS AND RAILCAR COMMITTEE

C. O. Guernsey—*Chairman*
A. W. Scarratt—*Vice-Chairman*
F. G. Alborn
C. O. Ball
B. B. Bachman
L. R. Buckendale
W. K. Creson
M. C. Horine
S. Johnson, Jr.
W. L. Moreland
C. A. Peirce
Fred L. Sage
H. E. Simi
C. W. Spicer

Research Committees

RESEARCH COMMITTEE

R. R. Teetor—*Chairman*
H. W. Alden
B. B. Bachman
D. P. Barnard
A. L. Beall
T. A. Boyd
G. C. Brown
R. W. Brown
H. M. Crane
C. L. Cummins
H. C. Dickinson
J. B. Fisher
H. L. Horning
J. H. Hunt
H. M. Jacklin
W. S. James
Ferdinand Jehle
F. F. Kishline
W. E. Lay
B. J. Lemon
G. W. Lewis
L. C. Lichty
J. B. Macauley
Neil MacCoull
G. L. McCain
C. A. Michel
F. C. Mock
Arthur Nutt
C. R. Paton
R. F. Peo
T. B. Rendel
V. P. Rumely
A. J. Scaife
T. C. Smith
H. C. Snow
S. W. Sparrow
Alex Taub
C. F. Taylor
W. G. Wall
E. P. Warner
F. E. Watts
J. F. Winchester
A. M. Wolf
H. T. Woolson

CRANKCASE OIL STABILITY COMMITTEE

J. B. Fisher—*Chairman*

D. P. Barnard
A. E. Becker
O. C. Bridgeman
A. W. Burwell
A. L. Clayden
H. K. Cummings
C. S. Fliedner
G. W. Gray
S. D. Heron
H. F. Huf
W. S. James
C. M. Larson
J. T. McCoy
H. C. Mougey
G. L. Neely
Frank Philippbar
T. B. Rendel
C. H. Schlesman
B. E. Sibley
T. C. Smith
K. W. Stinson
R. R. Teetor
E. W. Upham

EXTREME PRESSURE LUBRICANTS SUBCOMMITTEE

W. S. James—*Chairman*

SUBDIVISIONS

Automobile Group

H. C. Mougey—*Chairman*
H. C. Dickinson
W. H. Graves
J. L. McCloud
H. M. Northrup
E. W. Upham

Axle and Transmission Group

F. E. McMullen—*Chairman*

H. W. Alden
E. F. Davis
F. A. Nason
R. L. Rolf

Bearings Group

Ernest Wooler—*Chairman*

W. T. Murden
Haakon Styri
O. W. Young

Oils Group

R. E. Wilkin—*Chairman*

A. P. Anderson
M. R. Bower
M. B. Chittick
A. L. Clayden
P. G. Colin
F. B. Downing
J. C. Geniesse
E. W. Hutton
Herman Intemann
C. M. Larson
A. R. Lange
W. W. Lowe
K. G. Mackenzie
R. R. Matthews
G. M. Maverick
G. E. Merkle
G. L. Neely
C. R. Noll
W. H. Oldacre
G. A. Round

Operators Group

T. C. Smith—*Chairman*

L. V. Newton
A. M. Wolf

Truck Group

A. J. Scaife—*Chairman*

W. E. Day
W. P. Eddy

FRONT-WHEEL-ALIGNMENT SUBCOMMITTEE

B. J. Lemon—*Chairman*

Passenger Car Division

B. H. Anibal
H. E. Churchill
James Dykstra
W. R. Griswold
M. N. Halsey
C. D. Harter
J. M. Nickelsen
F. C. Pearson
E. G. Peckham
A. R. Platt
J. N. Prentis
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The Manly Memorial Medal shall be awarded annually to the author of the best paper relating to theory or practice in the design or construction of, or research on, aeronautic power-plants or their parts or accessories which shall have been presented at a meeting of the Society or any of its Sections during the calendar year.

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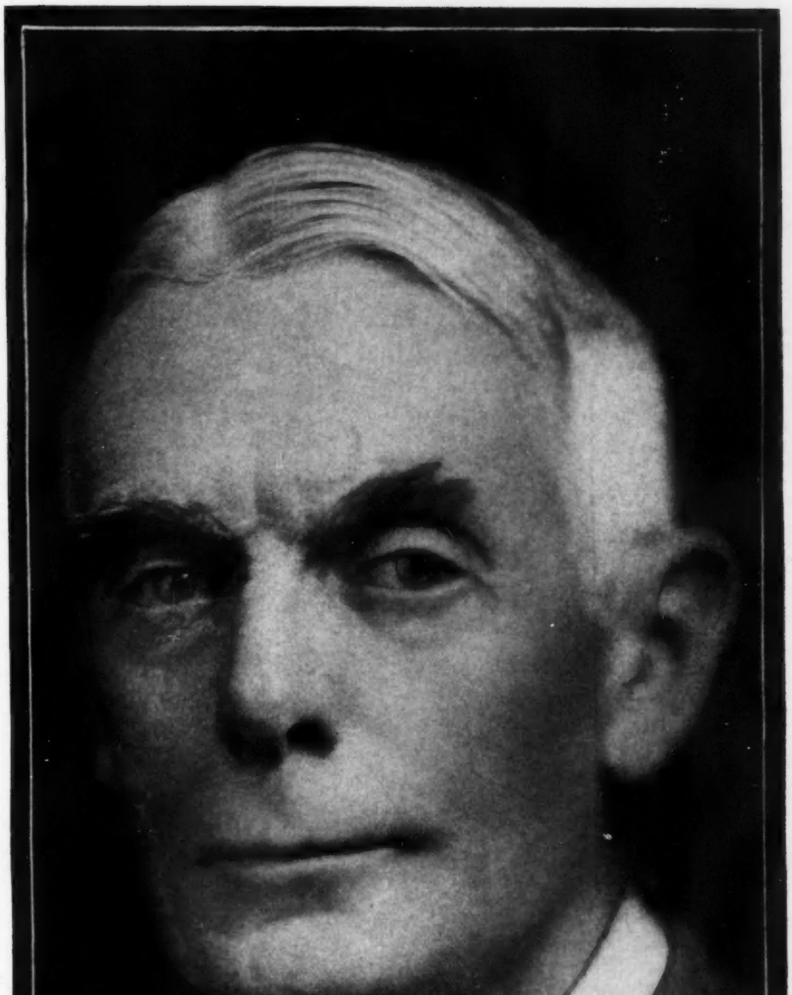

Mr. Crane's view (he is technical advisor to the president, General Motors Corp., and a past-president of the Society of Automotive Engineers) represents a spontaneous appreciation of one phase of the Society's activity. Other members find many other reasons for enthusiasm.

The ideals of every vocation in the automotive industry find concrete expression through the S.A.E.

New Members Qualified

These applicants who have qualified for admission to the Society have been welcomed into membership between Dec. 10, 1934, and Jan. 10, 1935.

The various grades of membership are indicated by: (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate Member; (SM) Service Member; (FM) Foreign Member.

AKERMAN, JOSEPH REID (J) mechanic, Walker-Durant Motor Co., Augusta, Ga.; (mail) 831 15th Street.

ANDERSON, JAMES WALKER, JR. (J) sales manager, Monarch Governor Co., 1847 Bethune Avenue, West, Detroit.

BAKER, ROBERT M. (J) air box operator, Bendix Stromberg Carburetor Co., South Bend, Ind.; (mail) 1156 Hillcrest Road.

BASS, ERNEST LEON (FM) chief engineer, aviation department, Asiatic Petroleum Co., St. Helens Court, London E. C. 2, England; (mail) 45 West Drive, Cheam, Surrey, England.

CATALANO, WM. A. (M) sales engineer, Standard Oil Co. of Ohio, Midland Building, Cleveland; (mail) 2886 Litchfield Road, Shaker Heights.

CLEAVER, GEORGE H. (M) superintendent, American Stores Co., 424 North 19th Street, Philadelphia; (mail) 200 Sylvan Avenue, Rutledge, Delaware Co., Pa.

DASKAL, GEORGE H. (M) secretary, Perfection Gear Co., 152nd Street and Vincennes Avenue, Harvey, Ill.

DIVELY, CLYDE A. (J) research laboratory assistant, White Motor Co., Cleveland; (mail) 3449 Glencairn Road, Shaker Heights.

FAHRNEY, EARLE G. (J) 623 Fair Oaks Avenue, Oak Park, Ill.

FAULKNER, FRED L. (M) automotive engineer, Armour & Co., Automotive Department, U. S. Yards, Chicago.

FLETCHER, J. S. (A) foreman, Commonwealth Oil Refineries, Melbourne, Victoria, Australia; (mail) 3 Service Street, Caulfield.

GEORGE, THOMAS CARL (J) junior aeronautical engineer, Naval Aircraft Factory, Philadelphia Navy Yard, Philadelphia; (mail) 3850 North 18th Street.

GOLDSMITH, LESTER M. (M) consulting engineer, Atlantic Refining Co., Philadelphia; (mail) 260 South Broad Street.

HUNTING, HERBERT (J) assistant engineer, W. T. Fishleigh, Consulting Engineer, Detroit; (mail) 388 Richton Avenue, Highland Park, Mich.

HUTCHINSON, ROBERT HALLER (FM) chief engineer, De Havilland Aircraft Co., Ltd., Stag Lane, Edgware, Middlesex, England.

JOHNN, CECIL CH. WILLIAM (FM) engineer, Shell Co. of Egypt, Ltd., Cairo, Egypt.

KAUFFMANN, ALFRED (M) Auburn Automobile Co., Auburn, Ind.; (mail) 701 North Main Street.

KAY, TORRENCE D. (J) chemist, United Petroleum Corp., 20th & Williams Street, Omaha, Nebr.

KRAMER, C. RAYMOND (J) engineer, Chance Vought Corp., East Hartford, Conn.; (mail) 71 Ensign Street.

LAAS, EUGENE (J) mechanic, Theodore Luce, 533 West 57th Street, New York City; (mail) 1910 McGraw Avenue.

LACHAPELLE, ROBERT LESTER (J) teacher, St. Cloud Reformatory, St. Cloud, Minn.; (mail) Little Falls, Minn.

MACMILLAN, HARRY L. (A) sales manager, National Motor Bearing Co., Inc., 1100 78th Avenue, Oakland, Calif.

MALONEY, JOHN SCOTT (J) draftsman, Rolls-Royce of America, Inc., Springfield, Mass.; (mail) 562 Enfield Street, Thompsonville, Conn.

MOLNAR, ERNEST (J) 245 Barthman Avenue, Columbus, Ohio.

MORRISON, JOHN W. (M) assistant engineer, Cleveland Wire Spring Co., Cleveland; (mail) 1281 East 38th Street.

NARGI, JOHN J. (J) draftsman, Chevrolet Motor Co., Detroit.; (mail) 92 Peterboro.

OZAWA, MITSUTARO (FM) automotive engineer, Tokyo Gas & Electric Engrg. Co., Ltd., Iriarai-machi, Omori-ku, Tokyo, Japan; (mail) 30 Minami-machi Takanawa, Shiba-ku.

PAPPAS, COSTAS ERNEST (J) graduate student, New York University, New York City; (mail) 9-34 122nd Street, College Point, N. Y.

PAUL, W. H. (M) instructor, mechanical engineering, Oregon State College, Corvallis, Ore.; (mail) 25 North 27th Street.

RADOW, HIMAN (J) 876 Dayton Avenue, St. Paul, Minn.

RUSSELL, FREDERICK C. (A) owner, Russell Service, 115 Walbridge Road, West Hartford, Conn.

SCHROEDER, WILBUR K. (J) Blocksom & Co., Michigan City, Ind.; (mail) 804 Cedar Street.

SCHWEIGLER, HARRY EDWARD (J) student engineer, Aeronautical University, Chicago; (mail) 1333 Touhy Avenue.

STIEGLITZ, WILLIAM I. (J) assistant to Mr. Smith, Bruce Smith, Aeronautical Engineer, 1338 South Michigan Avenue, Chicago; (mail) 529 South Linden Avenue, Highland Park, Ill.

TATSUYE, Y. (J) assistant engineer, Tokio Gasudenki Co., 100 Iriarai, Omori, Tokio, Japan; (mail) 653 Kitasenzoku.

TAYLOR, FRANK HOWARD (J) automotive engineer, Texas Co., 135 East 42nd Street, New York City; (mail) 233 South 14th Street, Allentown, Pa.

TIJKEN, ROBERT (FM) 27 Spotvogellaan, The Hague, Holland.

TRAUTMANN, WALTER C. (J) engineering student, Bruce Smith, Consulting Engineer, Chicago; (mail) 4325 Vista Terrace.

TRUMP, FREDERICK O. (J) mechanical engineer, 327 West 88th Street, New York City.

ULMANN, ALEXANDER EDWARD (A) export sales manager, Multibestos Co., Cambridge, Mass.

WALSH, THOMAS E. (A) president, Walsh Advertising Co., Ltd., 211 Guaranty Trust Building, Windsor, Ontario, Canada.

WAY, E. G. OWEN (J) chemist, Shell Oil Co., 3522 Sherbrooke Street, East, Montreal, Quebec, Canada.

WHEATON, FLOYD L. (A) acting superintendent, automotive maintenance, City of Detroit, Dept. of Street Railways, 14200 Second Avenue, Highland Park, Mich.

Applications Received

The applications for membership received between Dec. 15, 1934, and Jan. 15, 1935, are listed herewith. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

AUL, RUSSELL W., superintendent transport, Jersey Central Power & Light Co., Asbury Park, N. J.

BERSHAD, ALFRED, 1863 72nd Street, Brooklyn, N. Y.

DEACON, BRUCE WELLINGTON, sales engineer, D. A. Stuart Co., Chicago.

DEVEREUX, WALLACE CHARLES, managing director, High Duty Alloys Ltd. and Magnesium Castings & Products Ltd., Slough, Bucks, England.

DONNELLY, JOSEPH A., district manager, The Autocar Co., Ardmore, Pa.

DOWNING, FREDERICK B., division head, E. I. duPont de Nemours & Co., Wilmington, Del.

HAZELL, ARTHUR MILES, assistant general supervisor, The Cudahy Packing Co., Chicago.

HOLBROOK, DARWIN L., sales engineer, Fafnir Bearing Co., New Britain, Conn.

HOWARD, ALFRED C., assistant general manager, Fairbanks Morse & Co., Beloit, Wis.

HURLEBAUS, GWYNN I., commodity chief purchasing officer, Department of Interior, Washington, D. C.

JENSEN, D. A., owner, Cords Piston Rings, Washington, D. C.

KERR, JAMES, service engineer, Associated Equipment Co. of Canada Ltd., Montreal, Que., Canada.

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KNOWLES, H. L., general superintendent, Imperial Oil Co., Sarnia, Ont., Canada.

KROLLE, SERGE L., 115 Connecticut Ave., Detroit.

McDONOUGH, EDWARD WM., aeronautical engineer, Goldammer-Wright Aircraft Co., Chicago.

McEVOY, MICHAEL AMBROSE, managing director, M. A. McEvoy Ltd., Derby, England.

MATTHEWS, THOMAS JOHN, engineer, Atlas Supply Co., Newark, N. J.

MEYER, MORRIS, foreman, Automotive Specialty Corp., Brooklyn, N. Y.

MILLER, WILLIAM EVERETT, service manager, Wilkening Mfg. Co. of Canada Ltd., Toronto, Ont., Canada.

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ROSÉ, ROWLAND S., assistant design engineer, Wentworth & Irwin, Portland, Oregon.

ROSSMANN, PETER F., engineer, Packard Motor Car Co., Detroit.

SABINA, JOHN R., automotive engineer, The Atlantic Refining Co., Philadelphia.

SJOLANDER, J. L., experimental engineer, The Cleveland Wire Spring Co., Cleveland.

STAFFORD, EDMOND W., general supervisor, Loose Wiles Biscuit Co., Chicago.

SWANSEN, THEODORE L., engineer, tractor division, Allis Chalmers Mfg. Co., Milwaukee, Wis.

TROSHKIN, ALEXANDER N., instructor, New York University, Bronx, N. Y.

WEBSTER, PHILIP SIDNEY, draftsman, Oliver Farm Equipment Co., Charles City, Iowa.

WOOD, HY., works manager, Canadian Johnson Motor Co., Peterboro, Ont., Canada.

Notes and Reviews

THESE items, which are prepared by the Research Department, give brief descriptions of technical books and articles on automotive subjects. As a rule no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

The letters and numbers in brackets following the titles classify the articles into the following divisions and subdivisions: *Divisions*—A, Aircraft; B, Body; C, Chassis Parts; D, Education; E, Engines; F, Highways; G, Material; H, Miscellaneous; I, Motorboat; J, Motorcoach; K, Motor-Truck; L, Passenger Car; M, Tractor. *Subdivisions*—1, Design and Research; 2, Maintenance and Service; 3, Miscellaneous; 4, Operation; 5, Production; 6, Sales.

AIRCRAFT

A Flight Investigation of the Lateral Control Characteristics of Short Wide Ailerons and Various Spoilers with Different Amounts of Wing Dihedral

By Fred E. Weick, Hartley A. Soulé and Melvin N. Gough. N.A.C.A. Report No. 494, 1934; 16 pp., 9 figs. Price, 10 cents. [A-1]

The Effect of Spray Strips on the Take-Off Performance of a Model of a Flying-Boat Hull

By Starr Truscott. N.A.C.A. Report No. 503, 1934, 18 pp., 9 figs. [A-1]

Airship Men Present Their Case

Published in *U. S. Air Service,* December, 1934, p. 26. [A-1]

A condensed report is here given of the high spots of testimony before the Federal Aviation Commission on the feasibility of the creation of scheduled commercial transoceanic airship transportation. Among those quoted are Carl Vinson, chairman of the House Naval Affairs Committee; Dr. Hugo Eckener; Rear Admiral H. I. Cone, head of the Shipping Board; Rear Admiral E. J. King, chief of the Bureau of Aeronautics; Brig. Gen. O. Westover, Assistant Chief of Air Corps; Paul W. Litchfield, president of the Goodyear-Zeppelin Corporation; Lieut. Comm. C. E. Rosendahl and Carl B. Fritsche, president of the Metalclad Airship Corporation.

La XIV^e Exposition Internationale de l'Aéronautique

By R.-J. de Marolles. Published in *Le Génie Civil,* Dec. 1, p. 497; Dec. 8, p. 524 and Dec. 15, 1934, p. 549. [A-1]

In the last three bi-annual Paris aircraft shows the number of aircraft exhibited has remained almost constant, about sixty, but the latest event shows a greatly increased foreign participation, about 40 per cent of the entries originating outside France.

In analyzing the status of aviation in France thus reflected, the author points out that the Government still remains aviation's sole important customer. He deplores the legislative restrictions on aviation, the high cost of aircraft, the lapse of time customary between the conception of a design and its realization in commercial form and the lack of private aviation.

The technical section of his article contains a general resume of aircraft design features and descriptions of individual types both domestic and foreign.

VI^e Tableau de l'Aéronautique Française—14^e Salon de Paris

By Pierre Léglise. Published in *L' Aéronautique,* December 1934, p. 287. [A-1]

In this table of the design characteristics of French aircraft designed between December 1933 and December 1934 are included data on 46 different models. This table and descriptions of the aircraft covered constitute the usual show number for the 14th Paris aircraft salon.

The Effect of Weight and Drag on the Sinking Speed and Lift Drag Ratio of Gliders

By R. Kosin. Translated from *Luftfahrtforschung,* Vol. 11, No. 5, October 25, 1934; Verlag von R. Oldenbourg, München und Berlin. N.A.C.A. Technical Memorandum No. 759, December, 1934; 7 pp., 3 figs. [A-1]

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ENGINES

Moteurs à Huile Lourde pour la Traction

By L. Keuleyan. Published in *Les Chemins de Fer et les Tramways*, December, 1934, p. 292. [E-1]

A competition of the Automobile Club of France for automotive Diesel engines is the occasion for this review of such engines, derived from the technical press and from private sources. A table of the design and performance characteristics and of the price of 29 Diesels, 8 of which are two-stroke cycle, is given as well as brief descriptions of the design of each of these engines.

Délai d'Inflammation des Combustibles dans les Moteurs à Combustion

By André Labarthe. Published in *Journal de la Société des Ingénieurs de l'Automobile*, November, 1934, p. 2934. [E-1]

In his general discussion of ignition lag, the author emphasizes that this or any other combustion phase must not be studied as an isolated phenomenon but considered in its relation to the entire field of fuel characteristics and engine design. His experiments have shown that neither the degree of atomization nor turbulence affect ignition lag, but that for a given fuel in a given engine the only factors influencing to any considerable degree the duration of the lag are the temperature and pressure of the air into which the fuel is injected. Primarily, ignition lag is said to depend on the character of the fuel, for the evaluation of which in this respect neither the ordinary inspection data nor chemical composition are significant. Future progress will come only through closer study of thermodynamic phenomena, is the author's prophecy.

Die Leistungssteigerung des Fahrzeugdieselmotors durch Druckladen und Zweitakt

A. E. Thiemann. Published in *Automobiltechnische Zeitschrift*, Dec. 10, 1934, p. 591. [E-1]

Only through increased specific performance obtained by means of scavenging, supercharging and the adoption of the two-stroke cycle will automotive Diesels win wider acceptance in the United States. With this premise, the author quotes from experiments designed to show the effect on the weight of engine charge of scavenging and supercharging.

Four reasons for the failure of the utilization of the two-stroke principle in automotive Diesels are discussed both theoretically and with reference to designs developed. The superiority of the supercharged four-stroke cycle Diesels for high performance automotive and aircraft engines is conceded.

Piston Temperatures on a High-Speed Air-Cooled Petrol Engine

By H. Wright Baker. Published in *Institution of Automobile Engineers Journal*, January, 1935, p. 47. [E-4]

The present paper is a continuation of the author's previous report upon the operating temperatures of small pistons and the factors upon which these temperatures depend. A new test bed has been installed and this as well as other test apparatus and methods are described.

Pistons of 3⅞ in. diameter have been tested in both air and water-cooled cylinders and at speeds up to 4000 r.p.m. to determine the effect of 11 variables of design and operating conditions on temperatures.

Typical test results are given and discussed and an endeavor made to correlate them with values previously recorded.

MATERIAL

"Exanol" Additions Markedly Better Temperature—Viscosity Charactertistics of New Engine Oils

Published in *Automotive Industries*, Nov. 17, 1934, p. 616. [G-1]

Extensive research has led to the development and production of "Exanol," polymerization products of the light ends of refinery gasoline. These products are clear and colorless, pure hydrocarbons which are said to have the property of increasing the viscosity index of any mineral oil to which they are added, thereby lengthening oil life, and improving performance.

Solvent Refined Oils Help Solve Some Engine Design Difficulties

By Arch L. Foster. Published in *National Petroleum News*, Nov. 7, 1934, p. 45. [G-1]

Solvent refined oils have higher voscosity index ratings allowing the use of a lower viscosity oil in a given engine at a given time. It is pointed out that lighter oils pass through the bearings in greater volume from the bearings, giving better lubrication and resulting in longer life.

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Year Book Section, American Institute of Mining and Metallurgical Engineers, Inc., 1935

Published in *Mining and Metallurgy*, January 1935, Section 2. [G-1]

This Year Book contains the roster of officers and principal standing committees of the American Institute of Mining and Metallurgical Engineers, Inc., brief summaries of the proceedings of the more important meetings, abstracts of papers published during the year and a classified list of technical publications and contributions as well as an index of all material published by the Institute in 1934.

Tabulated Analyses of Texas Crude Oils

By Gustav Wade. U. S. Bureau of Mines Report of Investigations No. 3252, December, 1934; 40 pp., 1 fig. [G-1]

Analyses of samples of crude oil from several Texas oil fields have been published but many others have not been published. This paper makes available in condensed tabular form all analyses of the Texas crude oils that have been examined by the Bureau of Mines.

X-Rays—What Should We Know About Them?

By George L. Clark. Published in *Electrical Engineering*, January, 1935, p. 3. [G-1]

Part of the American Institute of Electrical Engineers "Science Series for Engineers," this article is designed to give to engineers not specialists in this field a general informative background on the use of X-rays.

Topics discussed are the nature of the rays, the mechanism of their production and the principles underlying their applications in many fields, particular emphasis being laid on their use in determining the ultimate fine structure of materials.

X-Ray Inspection of High Alloy Castings

By F. K. Ziegler and D. W. Bowland. Published in *Metal Progress*, December, 1934, p. 22. [G-1]

The foundry company with which the writers are connected has adopted the X-ray apparatus as an integral part of its inspection of nickel-chromium castings, such final check of visual inspection being considered necessary where, as in making alloy castings of widely varying and rapidly changing designs, all factors of production can not be controlled.

The making and interpreting of the X-ray films are described, illustrative films presented and defects found are discussed.

Lubrication for Anti-Friction Bearings

By O. L. Maag. Published in *American Machinist*, Nov. 7, 1934, p. 770. [G-1]

A discussion of the various types of oils and greases, new developments in lubricants, and methods of applying the lubricant, in a brief review.

A Method for Evaluating the Viscosity-Temperature Characteristics of Oils

By W. B. McCluer and M. R. Fenske. Published in *Industrial and Engineering Chemistry*, Nov. 15, 1934, p. 389. [G-1]

The purpose of the paper is to outline a method by means of which the viscosities of different oils may be compared quantitatively, either at low temperatures encountered in winter starting or at the high temperatures encountered during motor operation.

Oxidation, Lubrication, and the Blending of Mineral Oils to Obtain Maximum Lubricating Value

By R. O. King. Reprinted from the *Journal of the Institution of Petroleum Technologists*, February, 1934; 41 pp., with tables and charts. [G-1]

Mr. King presents a discussion of the mechanism of lubrication and attempts to show a correlation between "oiliness" and the oxidation characteristics of the oil blend. The conclusion is that the blending of oils for optimum performance depends on a selection of constitutents to maintain the necessary oxidation activity in the blend over the range of temperature required in use.

L'Huile de Graissage et la Mise en Marche des Moteurs: les Huiles d'Hiver

By Henri Petit. Published in *La Vie Automobile*, Nov. 25, 1934, p. 582. [G-1]

The necessity for special winter engine oils is discussed under the headings of the variation of viscosity with temperature and the effect of oil viscosity on the ease of engine starting. The characteristics of 9 commercial special winter oils are briefly set forth, and the use of graphite and upper cylinder lubrication referred to.

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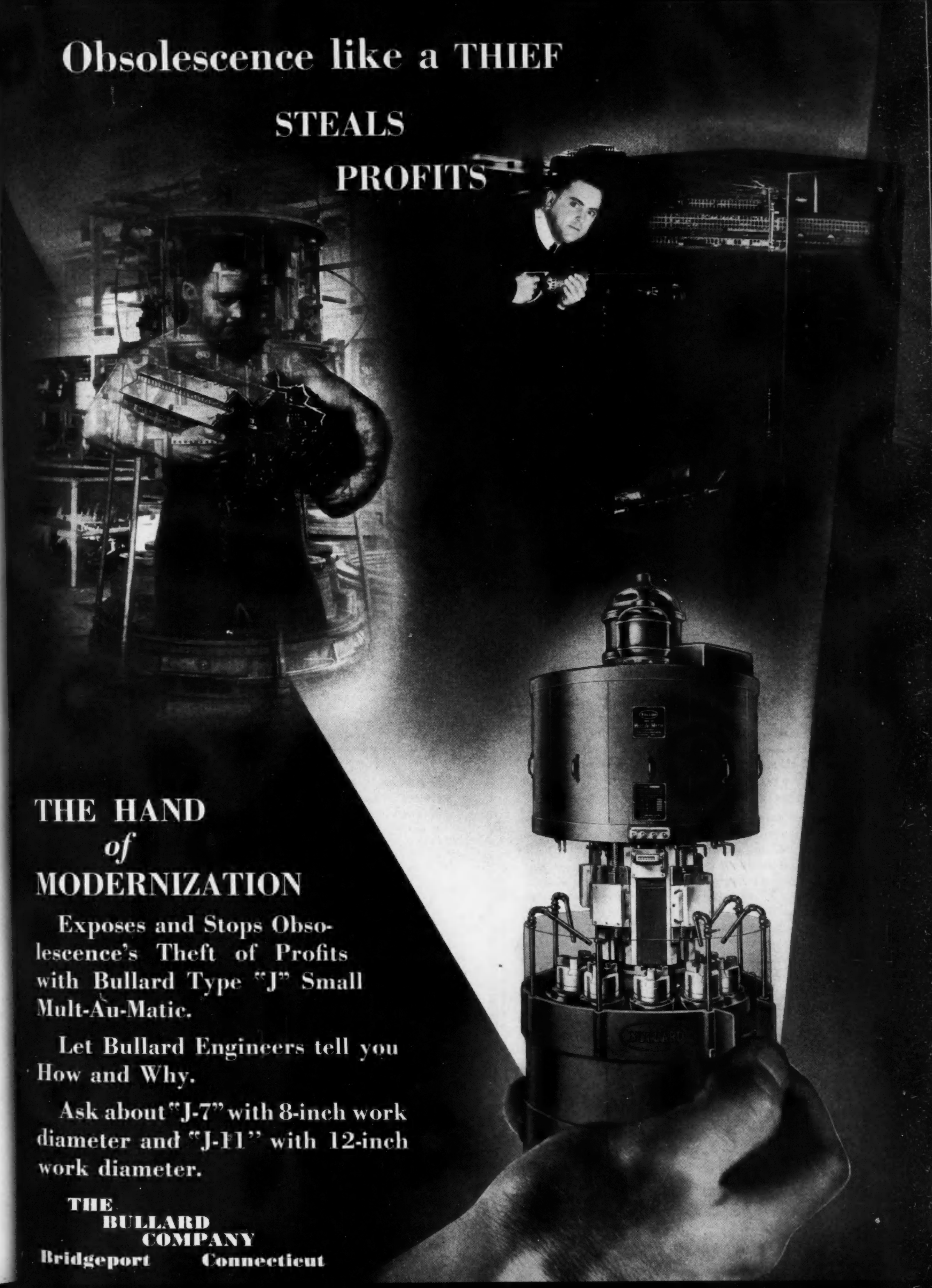
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NOTES AND REVIEWS

Concluded

MOTORBOAT

What's New?

Published in *Motorboat*, January, 1935, p. 11. [I-1]

Among the trends noted in boat design in this preview of 1935 offerings are greater emphasis on the smaller types of cruising boat and less on the inboard runabouts, lack of radical departures in design and construction, more speed with less power and streamlining.

Engines show higher maximum rotative speeds with increase in popularity of reduction gearing, and a salient trend toward the eight-cylinder V-type developing 100 hp. or less. Fuel oil engines other than Diesels are also being offered.

Descriptions are also given of manufacturers' current commercial products grouped into the three divisions of boats, engines and accessories.

MOTOR-TRUCK

Equalizing Carrier Competition

Published in *Railway Age*, Dec. 1, 1934, p. 691. [K-4]

Two planks constitute the platform here advocated to restore the net earnings of the railroads: 1. Equalize the public regulation of rates, services, accounting and operating practices as between the railroads and their highway and waterway competitors, and 2. Eliminate subsidies now being provided for carriers by highway and waterway.

Issue is taken with those who claim that the competitive traffic losses of the railroads are small, such losses being estimated here as one billion dollars annually. In discussing highway costs attributable to heavy commercial vehicles, the statement is made that road costs made necessary to accommodate vehicles weighing with load in excess of 2½ tons are from 40 to 50 per cent higher than they would otherwise be. Both Federal and State legislation is recommended.

PASSENGER CAR

A Study of Road Performance

By Maurice Platt. Published in *Institution of Automobile Engineers Journal*, January, 1935, p. 13. [L-1]

As technical editor of an English automotive journal, the author is responsible for carrying out road trials of private cars of all sizes to the number of about 35 annually. He is also partly responsible for the tests made by other members of the editorial staff.

In this paper he summarizes this road-test experience in two ways: first, by presenting average performance figures for various classes of car, based upon a large number of tests; and secondly, by stating personal opinions upon features of performance not easily measurable, such as steering characteristics and riding-qualities.

The technique of road testing is also discussed.

Bullard-Dunn Process Used to Clean Car Parts

Published in *Iron Age*, Dec. 20, 1934, p. 28. [L-5]

This article describes an installation of equipment which, by means of an electrochemical process, cleans parts at a lower cost than wire brushing and results in an improved quality of product. The cleaning equipment is entirely automatic and reaches otherwise inaccessible crevices, joints and small holes in the parts to be cleaned.

General Motors Trains the Foremen

By W. S. Knudsen. Published in *American Machinist*, Dec. 5, 1934, p. 824. [L-5]

The author believes that the foreman should be more thoroughly trained so that he may more keenly realize his responsibilities, his authority and his relation to the men under him. The foreman is closest to the worker, and trained foremen reduce labor trouble.

Heat-Treating in an Automobile Plant

By J. B. Nealey. Published in *Machinery*, December, 1934, p. 201. [L-5]

Thirty-two gas-fired furnaces installed in a building 400 ft. long by 50 ft. wide perform the heat-treating operations described in this article. Among the topics discussed are a continuous pusher type of annealing furnace, controlled with extreme accuracy, the forging of gear blanks, routing, quenching and furnace control methods.

Needle Bearings and Their Applications

By Herbert Chase. Published in *Production Engineering*, December, 1934, p. 461. [L-5]

Needle bearings are defined as roller bearings wherein the rollers are fairly long in proportion to their diameter. The advantages and production status of this type of bearing are touched on and applications in the automotive and other fields enumerated. Other topics are installation technique, multiple rollers, loads and lubrication.